BLM LIBRARY
88010863

PLANNING FOR NON-RENEWABLE COMMON MINERAL RESOURCES IN URBAN-SUBURBAN ENVIRONS

Rensselaer Polytechnic Institute

Troy, New York

TN
153
.B57
1969

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

#6374289

88010863

TN
153
.B57

PLANNING FOR NON-RENEWABLE
COMMON MINERAL RESOURCES IN
URBAN-SUBURBAN ENVIRONS

by

Donald Bishko*
Assistant Professor of Industrial Administration
and Computer Science
Union College

James R. Dunn
Professor of Geology
Rensselaer Polytechnic Institute
and
William A. Wallace
Associate Professor of Management
and
Director, Urban - Environmental Studies
Rensselaer Polytechnic Institute

This report was prepared for the
Division of Mineral Economics, U. S.
Bureau of Mines, Department of the
Interior, Washington, D. C.

Urban - Environmental Studies
Rensselaer Polytechnic Institute
Troy, New York
October 18, 1969

---

*Work on this project was conducted while this author was a Computer Specialist for the U. S. Bureau of Mines.

PROPERTY OF
Bureau of Land Management
DSC LIBRARY

ABSTRACT

PLANNING FOR NON-RENEWABLE COMMON MINERAL RESOURCES IN URBAN-SUBURBAN ENVIRONS

A Research Report Prepared for the Division of Mineral
Economics, Bureau of Mines, by Renssalaer Polytechnic Institute,
Urban - Environmental Studies Program

A computer simulation model was developed that enables a planner to investigate the effects of various zoning strategies on common mineral resources. For example, it allows him to analyze the likely course of development in the absence of zoning or, alternatively, the results of a policy limiting individual operations and forcing the removal of material from a site before it is covered by urban development. ("Effects" and "results" are defined in terms of added costs of delivered sand, gravel, etc.) The model does not attempt to search for decisions which yield "optimal" solutions; it rather indicates the results of a (simulated) time period of various planning strategies, thus providing the planner with greater insight into the effects of the decisions that he alone can make. The model allows for almost any pattern of (1) urban - suburban growth over time and (2) mineral resource supply.

The model was run and tested on the Tri-City Area (Albany, Schenectady and Troy, New York). From this pilot study it was observed that this area was insensitive to selected zoning changes, largely because of the abundance of mineral aggregate resources. Under hypothetical test conditions reducing the number of suppliers, the results of the model were very sensitive to zoning changes and the relative position of supply and demand points.

Although the model developed in this research has been designed specifically for studying common mineral resources, it can be extended to become part of a more general land use model. Furthermore, the ideas and methodology used in its development can (and should) be applied to studying any non-renewable, fixed position resource as part of an evaluation of multiple land use.

TABLE OF CONTENTS

Page

LIST OF TABLES vii

LIST OF FIGURES viii

ACKNOWLEDGEMENTS ix

ABSTRACT xi

I. INTRODUCTION 1

1.10 Description of the Problem 1

1.20 Research Objectives 7

1.30 General Discussion of Report Format 8

II. ECONOMIC AND TECHNOLOGICAL BACKGROUND 10

2.10 Introduction 10

2.20 Production 12

2.30 Consumption 16

2.40 Transportation 18

2.50 Reclamation and Multiple Land Use 19

2.60 Urban Planning and Zoning 23

III. RESEARCH METHODOLOGY 26

3.10 Introduction 26

3.20 Simulation - A General Description 27

3.30 Simulation and Urban Problems 30

3.40 Simulation and the Mineral Resources 33

3.50 Specific Computer Simulation Techniques . . 34

3.51 Model Formulation 34
3.52 Language and Model 38
3.53 Assembly Language Techniques 41

Page

3.60 Pilot Study 44

3.61 Model Validation. 46
3.62 Data Collection 47
3.63 Pilot Study Area. 49

IV. MIRSIM (MINERAL RESOURCE SIMULATION MODEL). . . . 51

4.10 General Description of the Simulation Process 51

4.20 General Overview of MIRSIM. 55

4.30 Input Control Section (MINEINPT). 56

4.40 Self-preservation Model (BEGINIT) 62

4.41 The Buyers' Influence on Quarry Location. 64
4.42 Cost Determination. 65
4.43 The Processing Plant. 67
4.44 Allowance on Existing Processing Plants. 67
4.45 Center of Demand Activity 68
4.46 The Processed Sand and Gravel Operation 70
4.47 The Unprocessed Sand and Gravel Operation 78
4.48 The Crushed Stone Operation 79

4.50 Date Processing Section (MINEDP). 80

4.51 The Data Processing Function. 80
4.52 The Quarry Assignment Model (SRFLCO). 82
4.53 New Quarry Selection Model. 84
4.54 End of Period Adjustments 85

4.60 Subroutines (MINESUBR). 86

4.61 Subroutine Find Lowest Cost Potential Quarry (SRPQCOST) 86

V. MODEL INPUT 88

5.10 Supply Data 88

5.20 Transportation Costs. 97

5.30 Demand Data 97

Page

5.40 A Molecular Method for Determining Future Mineral Aggregate Consumption. 98

5.41 Forecasting the Number of Residential Units. 101
5.42 Concrete Requirements for Residential Construction 106
5.43 Forecasting the Floor Area of Non-Residential Construction 106
5.44 Concrete Requirements for Non-Residential Construction 108
5.45 Determining the Quantities of Sand and Gravel for Residential and Non-Residential Construction 111
5.46 Determination of Aggregate Quantities for Roads 111

VI. RESULTS AND CONCLUSIONS. 113

6.10 Validating Procedures. 113

6.11 Input Data Validation. 113
6.12 Model Validation 117
6.13 Output Validation. 119

6.20 Analysis of Generated Output 122

6.30 Experimentation With New Operating Techniques 131

VII. SUMMARY AND SUGGESTIONS FOR FUTURE RESEARCH. . . . 133

7.10 Summary. 133

7.20 Suggestions for Future Research. 138

7.30 An Addendum: An Investigation of the Mineral Resources in the Syracuse, New York Metropolitan Area 142

BIBLIOGRAPHY 145

APPENDIX A. USER' GUIDE 151

A.1. General Program Layout 151
A.2. Option Card. 153
A.3. Transportation Cost Curve. 156
A.4. Outside Quarry Information Card. . . . 157
A.5. Grid Information Input Card. 158
A.6. Intermediate Grid Information. 164
A.7. Sample Output. 166

Page

APPENDIX B. PROGRAMMER'S GUIDE. 169

B.1. General Information. 169
B.2. Matrix Configuration 169
B.3. Core Size Requirements 174
B.4. Subroutines. 175

APPENDIX C. DETAILED FLOW DIAGRAMS. 179

APPENDIX D. SOURCE PROGRAM. 202

LIST OF TABLES

Page

TABLE 4.1. PROCESSING PLANT ALLOWANCES. 68

TABLE 4.2. SINGLE QUARRY OPERATION DECISION EXAMPLE . 72

TABLE 4.3. MULTI-QUARRY OPERATION DECISION EXAMPLE. . 75

TABLE 5.1. CONCRETE REQUIREMENTS VS. LOT AND HOUSE SIZE. 102

TABLE 5.2. HOUSING SIZES IN THE STUDY AREA. 103

TABLE 5.3. EXAMPLE CONCRETE REQUIREMENTS ON SELECTED STRUCTURES. 108

TABLE 6.1. TRANSPORTATION COST ANALYSIS 126

TABLE 6.2. RESULTS OF MASSIVE ZONING CHANGES. 127

TABLE 6.3. RESULTS OF REALISTIC ZONING CHANGES. . . . 130

LIST OF FIGURES

Page

FIGURE 3.1. GRID OVERLAY. 35

FIGURE 3.2. RING AND ZONE OVERLAY 35

FIGURE 3.3. PICTORIAL REPRESENTATION OF SEARCH PROCEDURE (FORTRAN) 42

FIGURE 3.4. ASSEMBLY LANGUAGE SEARCH PROCEDURE. . . . 43

FIGURE 3.5. EXAMPLE OF GRID OVERLAYS. 44

FIGURE 3.6. TRI-CITY AREA MAP 50

FIGURE 4.1. EXAMPLE STUDY AREA WITH GRIDS 51

FIGURE 4.2. STUDY AREA WITH SUPPLY AND DEMAND LOCATIONS 52

FIGURE 4.3. FIGURE 4.2. WITH GRID OVERLAY 53

FIGURE 4.4. SECTION LINKAGE FLOW DIAGRAM. 57

FIGURE 4.5. GENERAL FLOW DIAGRAM. 58

FIGURE 4.6. CHAINING EXAMPLE. 61

FIGURE 5.1. APPROXIMATE LOCATIONS OF QUARRY OPERATIONS IN TRI-CITY AREA. 96

FIGURE 6.1. EXPERIMENTAL TRANSPORTATION COST CURVES . 125

FIGURE 6.2. EXPERIMENTAL REALISTIC ZONING CHANGES . . 129

ACKNOWLEDGEMENTS

It would be difficult to acknowledge all those who cooperated in the development of this report. Constant guidance of the overall research endeavor by personnel of the Division of Mineral Economics, U. S. Bureau of Mines, in particular, Dr. David B. Brooks, Chief, was greatly appreciated. In addition, Mr. Donald Frendzel, then of the Pittsburgh Office of Mineral Resources, U. S. Bureau of Mines, was instrumental in the initial model development and data collection.

At Rensselaer a list of people associated with the project includes Shimon Awerbuch who was responsible for gathering demand data and developing the methodology for forecasting mineral aggregate requirements. Rolph Schlake continued the work started by Don Frendzel and provided the final data concerning quarries and potential supplies, and William Cutcliffe of J. R. Dunn & Associates supplied us with the geological information on the Tri-City Area.

Special thanks must be given to Dr. James Davis, New York State Geologist, and the members of his staff for their cooperation and evaluation. Planning for mineral resources requires the guidance and involvement of state geological surveys for meaningful results. We received this (and more) throughout the course of the study.

Personnel at Rensselaer's Computer Center were most cooperative. In particular, the assistance provided by Messrs. Tom Duchesneau, Mel Sabel and Al Budka must be acknowledged.

The data collection process was greatly facilitated by the assistance provided by Mr. Kenneth Shiatte, Director of the Subdivision of Transportation Planning of the State of New York, and Messrs. B. Zodikoff and R. Brustman, Transportation Analysts of the New York State Department of Transportation. Other data was provided by Mr. L. Parker, Schenectady County Planner; Messrs. D. Ruddy and W. McGloughlin of the District I Office of the New York State Department of Transportation; and Mr. J. McDonough of the Portland Cement Association. Also the assistance of Mr. Douglas A. Fuess, Executive Secretary of the Empire State, Sand, Gravel and Ready Mix Association, Inc., and Mr. Clifford V. Tobin, Executive Secretary of the New York State Crushed Stone Association, Inc., was extremely valuable.

ABSTRACT

The problem of conserving or allocating common mineral resources is rarely considered by those who plan the destiny of our urban environment. The purpose of this research is twofold: (1) to delineate in dollar terms the magnitude of the result of not planning for the consumption of common mineral resources, and (2) to develop a computer simulation model which will provide planners with an indication of the effects of decisions affecting these resources.

The construction mineral aggregates with which this research is specifically concerned (sand, gravel, and crushed stone) are among the earth's most plentiful, yet are rapidly being rendered inaccessible in those areas which need them most. They are characterized by a low intrinsic value, a high bulk, and a delivered price which is very sensitive to the transportation cost associated with moving it from the quarries to their points of demand. It is ironic that the cities which create the demands for mineral aggregates are, at the same time, preventing their extraction by being built over them or by legally limiting their use through zoning restrictions.

The simulation model which has been developed enables the planner to investigate the effects of various zoning strategies. It allows him to investigate the results of limiting individual operations, and to force the removal

of material from a site before it is covered by urban development. It does not attempt to search for decisions which yield "optimal" solutions; rather it indicates the results, over a (simulated) time period, of various planning strategies, thus providing the planner with greater insight into the effects of the decisions that he alone can make.

In order to provide the model with the data of the urban area being studied, the geographic region is subdivided into a number of rectangular grids and the characteristics of each grid fed into the computer. Such characteristics as the location, type, and reserves of all quarries and potential quarries and the location, type, aggregate requirements, and starting year of all construction projects are required as input data.

The computerized model described in this research is programmed in IBM/360 Assembly Language to provide, from a computing viewpoint, an efficient program which is capable of anaylzing a large number of grids. The program requires approximately 100,000 characters of core storage for a study area encompassing 1,000 grids; peripheral storage such as tape or disc is not required.

The model has been run and tested on the Tri-City area (Albany, Schenectady, and Troy, New York). From this pilot study, a number of observations have been made; some concerning the model itself, and others specifically pertinent to the study area.

The Tri-City area has an abundance of very strategically situated mineral aggregate producers, most of which have more than adequate reserve deposits. Potential reserves are also abundant, and present zoning restrictions do not interfere to any appreciable extent with the existing supplies. As a result, the study area proved to be quite insensitive to the experimental changes that were made during the simulation runs.

Under hypothetical test conditions where the quarry suppliers were few in number, the model was very sensitive to zoning changes and the relative position between supply and demand points. Hence, the accuracy and detail with which data should be collected is a function of severity of the mineral resource problem within the area being studied.

Although the model developed in this research has been designed specifically for studying common mineral resources, it can be extended to become part of a more general land use model. Furthermore, the ideas and methodology used in its development can be applied to studying any non-renewable, fixed position resource.

CHAPTER I

INTRODUCTION

1.10 Description of the Problem

We read daily of the problems facing the metropolitan areas of the United States; of slums, overcrowding, civil rights, air and water pollution, noise and dust control, and many more. Yet one is hard pressed to say that he is aware of another important problem: that the very materials from which a city builds its buildings, roads, and bridges are becoming increasingly scarce. Ironically, the materials to which we refer, sand, gravel, and stone are among the most plentiful in the earth's surface, yet they are rapidly being rendered inaccessible in those areas that need them most. The shortage is not that the earth contains no more mineral aggregates; rather, it is because roads and buildings have been built over them or zoning laws prohibit their being quarried where they are most needed. "The paradox of the sand and gravel industry is that the wave of highway and building construction, which has boomed the demand for its products, is at the same time making deposits less accessible" (ASPO Planning Advisory Service [1961], p. 1).

Sand, gravel, and stone are non-renewable, fixed position mineral resources. Their location is fixed by nature, and they cannot be created or replaced by the ingenuity of man. "They are characterized by a low intrinsic value, a high bulk, and an at market price highly sensitive to transportation costs" (Wallace, Dunn, and Bishko [1968], p. 1).

> The resources which are of concern to a city - water and construction materials - are measured in cents per 1,000 gallons, cents per yard, or cents per ton. They are commodities which are used in large volumes but which have a low value per unit of production. Of paramount importance, then, is the location of the resources - proximity to a city's growing parts (Flawn [1964], p. 3).

We begin to get an awareness of the transportation sensitive characteristic of these commodities. Continuing,

> One very important economic fact of life to remember about the minerals aggregates industries is that these minerals must be mined and processed near the market. Sand, gravel, and stone are high volume - low value products.
>
> Eighty percent of sand and gravel is shipped by truck to the market over distances of under 30 miles. It has been estimated that a hauling distance of 20 miles doubles the cost of delivered sand and gravel. Thus, relatively short additional hauling distances have a dramatic effect on the costs of aggregates and therefore on the cost of construction. Or to put it another way, vast reserves of stone or gravel in the Rocky Mountains have no value even for construction in Denver (Ahearn [1965], p. 2).

The problem of excessive transportation costs is mentioned mainly in qualitative terms. This research will, as it attempts to quantify the overall problem of planning for mineral commodities, investigate and experiment in great detail with the transportation aspect of the problem, particularly to its magnitude in dollar terms.

Goldman ([1961], p. 717) points out that the public suffers more than just absorbing excessive rates for delivered aggregates.

> Often the new deposits being worked at a great distance from the consuming center are of inferior quality when compared to the original source, yet they must be utilized because the expense of importing higher quality material from a more distant source would be prohibitive. Thus the quality of construction suffers and maintenance costs rise.

The population of the United States continues to grow, and with it grows the need for more and more building materials.

> To house the future population of the United States, to provide it with employment, education, health and recreational facilities, we must build an urban plant to take care of it. No longer will any appreciable portion of the land be able to provide for itself in a pioneering fashion, to live off the land, to strike out on its own. Providing this urban plant is a major task, if not the major task for the nation (O'Harrow [1962], p. 3).

"Each decade urban settlement extends over an additional 15,000 square miles of land in and around our metropolitan complexes" (Goldman [1959], p. 2). By a few years after the turn of the century, the population of the United States will exceed 350 million people (O'Harrow [1962], p. 2), the vast majority of whom will live in or around a metropolitan area. During the past ten years alone, we have witnessed a population expansion of over 30 million people.

"The use of sand and gravel, and of stone, follows a growth curve which locks like the curve of population growth" (ASPO Planning Advisory Service [1961], p. 1). It is estimated that "-in the streets alone of this urban development, we will use something on the order of 4 billion tons of sand and gravel. I feel that, conservatively estimated, you will have to produce over the next 30 years twice as much sand and gravel as you would if you stayed at your present capacity" (Bell [1962], p. 51).

As the growing population continues to seek metropolitan areas as their place of residence, the area of land over which they extend will increase. Increasing amounts of sand, gravel, and stone will be needed within these areas. If the present trend of not allowing quarrying within metropolitan limits continues, quarries will continue to be forced to move farther and farther away from their points of demand.

Dennis O'Harrow, Executive Director of the American Society of Planning Officials projected his thoughts on future zoning restrictions by stating:

> One of the most important resources needed to care for this next 100 million city dwellers is land. You can in the future expect to see land controls, zoning and subdivision regulations become even more widely used than they are now. I believe also that you (Sand & Gravel Association) will be subject to restrictions much tougher than those you presently have (Bell [1962], p. 52).

The problem facing planners was well presented by Vincent Ahearn, Jr. ([1965], p. 2) when he stated:

> The question is raised, therefore: Are we going to be able to meet this huge demand for aggregates during the next 30 years?
>
> Remember that these next 100 million people are going to live in urban areas. We are already in the midst of rapid horizontal expansion of our cities and suburbs. Instead of getting better, this expansion is going to accelerate, and every square mile it covers may contain (and frequently does), valuable deposits of sand, gravel, or stone which, when covered with suburban development, will be forever lost.

The magnitude of the problem within New York State was given dramatic proportions by Governor Nelson Rockefeller.

> During the next 20 years it is estimated that private and public builders will construct in New York State more physical facilities - factories, schools, highways, homes - than existed in the entire state in 1940 (Dunn and Broughton [1965]).

As a result of the forecasted shortage of construction aggregates, and what became the impetus of this research, Dunn and Broughton [1965] have proposed a mineral conservation ethic:

> Our major thesis is that waste and misuse of earth materials in our time can become a calamity; that it has many causes; and that prudent thought and action now can avert what we feel is a developing crisis in raw materials. This leads us to propose a "Mineral Conservation Ethic": ANY ACTION WHICH LEADS TO THE WASTE OR MISUSE OF A MINERAL RESOURCE IS A CONCERN OF THE GENERAL PUBLIC.

The knowledge that mineral aggregate supplies are becoming scarce is not enough to make the public act in their behalf; the added costs the community will have to pay because of this shortage can be a far more persuasive means of alerting public attention. Zoning laws are made by town boards, each looking after the needs within its own community and few seeing the "broader picture." This research is an attempt to provide a means by which the total future cost of mineral aggregates under various zoning strategies can be extrapolated and presented to the planners who makes the laws which control their usage. No effort is made to determine the utility of the lands on which quarries reside; rather, it is left to the planner to determine whether the cost differentials (in real dollars) can justify the utility differentials of the affected land.

1.20 Research Objectives

This research does not intend to substantiate (or even quantify) the fact that there is a geologic shortage of mineral aggregates; rather it is concerned with whether the problem is of economic concern, and if so what can be done about it. The objectives, therefore, are twofold: (1) to develop a technique by which dollar values can be attached to all costs associated with common mineral aggregate usage over a forecasted time period, and (2) to develop a planning model which will enable the planner to consider mineral resource allocation in the overall plan of regional growth.

The first objective of this research is to quantify the mineral aggregate costs that will be generated as a community grows over a forecasted time period (i.e. describe the magnitude of the problem). In order to accomplish this objective, it is necessary to describe the dynamics of the growth of the community and its relationship to the demands on the mineral resources which are capable of supplying it. A model is developed which uses as input the geologic data of the area being studied and the demands created by the forecasted urban growth.

A natural consequence of describing what will happen under existing conditions is describing what will happen under an alternative set (or sets) of conditions.

The ability to provide the planner a means by which he can ask "what will happen if?" and get an answer in a matter of minutes - rather than waiting to find out what would really happen and he actually implemented his plan - is the second major objective of this research.

The methodology used to accomplish these tasks is described in detail in Chapter III.

1.30 General Discussion of Report Format

Chapters I, II, and III contain a review of the literature pertinent to the research described in this report. Chapter I describes the problem and objectives of this research. Chapter II presents an overview of the mineral aggregate producer and consumer. It discusses transportation methods, reclamation, zoning, and the role of the urban planner.

Chapter III develops how simulation techniques can aid in the solution of problems of planning. Also discussed in this chapter are the problems encountered in establishing the simulation model, a discussion on the available computer languages, and the reasons for the necessity of a pilot area study.

Chapter IV deals with the specifics of the computer simulation model. It describes in detail the assumptions that were made and the decision processes included in the model.

Chapter V discusses the data collection process and suggests more efficient techniques which should be employed when conducting future studies on other areas.

Chapter VI presents the simulated output of the pilot area studies and summarizes the researchers' conclusions. Included in this chapter is a discussion of validation procedures employed in the model analysis.

A summary and discussion of the overall implications of the research and a guide for future studies is presented in Chapter VII.

Appendix A is a User's Guide. It includes all the details necessary for a "non-programmer" to prepare data for the model. Appendix B describes the model in a programming sense. This appendix, when used in conjunction with the detailed flow diagrams (Appendix C) and the program itself (Appendix D) will enable an experienced IBM System/360 Assembly Language programmer to make changes or additions to the model herein described.

CHAPTER II

ECONOMIC AND TECHNOLOGICAL BACKGROUND

2.10 Introduction

The mining industry is concerned with the removal of naturally occurring materials from above and beneath the earth's surface and some form of initial processing. These materials include: industrial minerals, ferrous and non-ferrous metals, coal, petroleum, natural gas, precious stones and metals, and construction aggregates.

The construction aggregates industry is by volume of materials produced, the largest of the mining industries in the United States today (Ahearn [1965]). The common mineral aggregates* (sand, gravel, and crushed stone) "consist of inert fragments which are added to a cementing material to form concrete. Their primary function is to provide bulk, and as such, they should be relatively abundant and cheap. Mineral aggregates include a variety of naturally occurring, manufactured, and by-product materials. Naturally occurring aggregates are those which are removed from the earth and processed without changing their characteristics or appearance" (Bottge [1964], p. 1). Manufactured materials (such as clay or shale) are removed from the earth and their characteristic or appearance is then changed. Processing the waste products of other industries yields by-products such as slag (a waste material from steel manufacturing). It is the naturally occurring aggregates with which this thesis is concerned.

---

*Specialty aggregates such as lightweight and heavy aggregates, decorative aggregates, etc., are minor in total tonnage and are not considered here.

The materials themselves are given quality classifications based on their chemical and physical properties. In order for a quarry to supply a given product, the quality of the aggregate produced must conform with the quality of material required by the contractor. In New York State, for example, State specifications usually require a high quality material.

In broad terms, mineral aggregates are produced (mined and processed) at the supply point (quarry) and shipped to the demand point (construction site) where they are used in the construction of our roads, buildings, bridges, etc. The price per ton paid by the buyer reflects the cost of the material, the variable costs associated with mining and processing it, the fixed costs associated with amortizing the processing plant, the future cost of land rehabilitation, profits to the quarry owner, and the transportation cost from quarry to the construction site. In oligopolistic situations where quarry suppliers are few in number, the competitive pressure which tends to keep proces down are minimal. In these situations, costs of delivered aggregates tend to be inflated.

2.20 Production

Sand and gravel quarrying is characterized by the removal of material from open pits (in the case of dry deposits) or by dredging when the materials lie under water. Crushed stone producers, on the other hand, work only dry deposits. This research considers three types of operations: (1) the processed sand and gravel operation, (2) the unprocessed sand and gravel operation, and (3) the crushed stone operation.

The processed sand and gravel producer will process his material at a processing plant which is located at the quarry site or at a processing plant located at another site (in which case the unprocessed material must be transported to the processing site for processing and then to the points of demand). This processing consists primarily of washing, sizing, possible crushing to various sizes, and stockpiling. Aggregates produced by the processed sand and gravel supplier are a high quality (usually state specified) material.

The unprocessed sand and gravel supplier sells his aggregates in an unprocessed form to be used as fill or sub-base material. After possible initial removal of overburden (topsoil) the material is sold in its natural form. In many cases, the unprocessed operator will allow individual contractors to remove their own material from his quarry, paying on a truckload rate.

Crushed stone production is characterized by blasting large volumes of relatively large pieces of rock from the parent rock, primary and secondary crushing to smaller pieces, sizing, washing and stockpiling. The crushed stone operation requires processing plants whose initial costs are relatively high in comparison with the sand and gravel plant. These plants are located at the quarry site.

Although they are not considered in this research, portable processing plants which can be moved from one quarry to another are also used in some sections of the United States, especially the Midwest. These plants eliminate the need for the operator to decide at which location(s) a fixed plant should be constructed.

Each quarry operator can supply from one to many demand points. Competition within the processed sand and gravel, unprocessed sand and gravel, and crushed stone operations exists. It is assumed that the buyer will select whichever quarry will supply the proper quality material at the lowest total cost. Although in reality, inequities such as political pressures, family ties, etc. exist, our model neglects these and considers only costs in determining project - quarry assignments.

Competition also exists between the crushed stone producer and the processed sand and gravel producer since some construction projects can use gravel or stone interchangeably. Our model does not consider this competition per se. Its effects, however, can be studied by varying project requirements on the data input (see Appendix A). There is also competition between the processed and unprocessed sand and gravel operations since high quality sand and gravel can be used as fill material. Because of the higher cost of the processed material, however, it is rare that this will happen.

Yearly production varies greatly from quarry to quarry. Quarries usually operate on an eight hour shift with operations terminating during the freezing months. Processed sand and gravel operations will supply from 50,000 tons to more than 1,000,000 tons per year. The unprocessed sand and gravel supplier will supply from as little as a few truck loads per year to 100,000 tons per year. Those quarries which are supplying large amounts of unprocessed material are usually located in the general vicinity of large construction projects. The crushed stone operator produces from 150,000 tons to over 1,000,000 tons per year. If yearly demands on a quarry greatly exceed the maximum yearly plant capacity, the operator can increase his maximum output by enlarging the existing plant or adding an entirely new plant. Although no major innovations are forecasted in the immediate future which will affect processing or mining methods, larger producers today are beginning to automate their operations by using central control rooms from which entire operations are monitored.

The entry of new producers into the marketplace is a function of demands created by the market and the availability of aggregate producing land which is able to provide material whose cost is competitive with other suppliers. Included in the economic determination of whether a quarry should be opened is: the type and size processing plant which will be required, the expected mining costs (based on the geologic configuration of the aggregate reserves), accessibility to transportation routes, and proximity to the market.

Based on the availability of material reserve land, new operations will often commence as the outgrowth of associated industries such as cement manufacturing, ready mix concrete, or simply a contractor who desires to produce his own material. This type of entry is not considered in this research.

2.30 Consumption

The construction industry in the United States, which accounts for slightly more than 10 percent of the Gross National Product (Jordan [1967], p. 7), creates the demand for mineral aggregates in the form of concrete and fill or sub-base material. Not only do new facilities such as roads, bridges, sewers, dams, buildings, etc. require concrete and fill, but there is also a demand created by the replacement and reconditioning of worn out structures. One cubic yard of concrete alone requires from 1200 to 2000 pounds of coarse aggregate (crushed stone or gravel) and 800 to 1500 pounds of fine aggregate (sand); the exact amounts are a function of physical size of the concrete section and the weather and exposure conditions affecting it (Portland Cement Association [1967]).

As examples of mineral aggregate usage, the concrete basement of a 30 X 40 ft. house would use 80 tons of mineral aggregates, and one mile of four lane highway requires from 60,000 to 100,000 tons of aggregates. The Verrazano-Narrows Bridge, connecting Brooklyn and Staten Island, required 378,000 cubic yards of concrete in the anchorages alone (Just, et. al.

[1964], p. 45), and a total of 710,000 cubic yards of concrete (Ammann [1964], p. 41), some 1,000,000 tons of mineral aggregates.

Since most mineral aggregate producers supply a market within their immediate vicinity, their market and growth is a direct function of construction activity in that area. In regions whose population is growing, demand is for both new construction as well as the reconditioning of existing structures; in areas whose population growth is static or declining, the majority of the demand is for the replacement of worn out facilities.*

The consumer of mineral aggregates can be as small as a man paving his driveway or as large as the Federal Government sponsoring the construction of a major highway complex. The job can require one truckload, or it may require many thousands of truckloads.

Demand points for mineral aggregates are much greater in number than are the supply points. Although it is not always the case, this research assumes that each construction project will receive its material from one processed sand and gravel quarry, one unprocessed sand and gravel quarry, and one crushed stone quarry. It is further assumed that each contractor will choose that quarry which will supply the proper quality material at the lowest total cost.

---

*Personal correspondence with Henry McCarl, Senior Analyst, Vulcan Materials, Co., Birmingham, Alabama.

2.40 Transportation

Transportation is the physical link between the producer and consumer. Three methods are presently being used to deliver aggregates to the construction site: 1) truck, 2) rail, and 3) barge. Of these, trucking is most widely used.* Although innovations in transportation techniques are not forecasted in the near future, one possible solution to the distance problem might very well be the development of new means of moving aggregates from quarry to construction site. This effect can be readily analyzed by varying the transportation cost parameter.

When large quantities of materials must be shipped over long distances, rail and barge are often used, depending on the proximity of the quarry to a rail or navigable water system. Even when aggregates are shipped by these methods, it is usually necessary to transfer the material to trucks at special unloading points for delivery to the construction site.

---

*In the U.S., nearly 90% of the sand and gravel and 70% of the crushed stone is shipped by truck to the demand points (U. S. Bureau of Mines [1963], pp. 1068, 1143).

Depending on the allowable axle weights established by the individual states, trucks transporting from 10 to 30 tons are usually employed. These trucks, which are usually a dump type, can be owned by either the quarry operator, the building contractor, or a truck leasing firm (or any combination thereof). Unloading costs are low since special unloading devices are not required as they are in the case of barge and rail.

In most cases, transportation charges are based on a ton-mile rate. Some companies, however, base their charges on a given rate from one zone to another, the rate being a function of transportation time as well as distance. Although these costs are sometimes lowered in order for a company to make their price more competitive, price negotiations of this type are not considered in our model.

2.50 Reclamation and Multiple Land Use

A necessary but not sufficient justification for allowing quarrying to continue within metropolitan limits is that the quarry site, once the operation has terminated, serves a positive value to its community. There is no doubt that the quarry of a few years ago was a strain on its community. It created noise, dust, safety hazards and detracted from the beauty of the surrounding area. To make matters worse, upon operation termination the community was usually left with a gaping hole in the ground or a dangerous cliff on the side of a mountain. It is no wonder that zoning ordinances in and around cities have historically prohibited quarrying.

Quarry operations today are becoming aware of the wants and needs of their surrounding areas. More and more are now building fences for safety, planting trees for beauty, paving access roads for dust control, and blasting only during certain hours to minimize the harmful effects of noise. Furthermore sites are being restored to a useful value upon operation termination. Speaking on reclamation in the sand and gravel industry, W. I. Thieme [1968], President of the American Aggregates Corporation and a pioneering leader in the area of reclamation stated;

> I have observed at work over recent years two important simultaneous trends. The first is the realization by the sand and gravel industry that its rights to mine this mineral resource carries with it the obligation to reclaim the excavated area. Great progress in this respect has been made by the industry in the last decade.

Further in the same speech, Mr. Thieme continued with:

> For the past five years the National Sand and Gravel Association has sponsored a research project on this subject at the University of Illinois which has received widespread

> national recognition.* Member companies which formerly regarded reclamation as a costly unnecessary expense now regard it as an integral part of their mining operations.
>
> Based on the University of Illinois research studies and our own company experience, we find it highly desirable to pre-plan reclamation rather than accomplish it after mining is finished. Overburden and surplus materials must be handled in the course of operations anyway, and it often costs little more to place it somewhere "on purpose" rather than elsewhere "accidentally". The result of this pre-planning often is lower costs and better more timely reclamation than would otherwise occur.

What exactly is reclamation as it applies to the sand and gravel industry? Speaking on this topic, Thieme [1969] suggests:

> According to Webster, the word "reclamation", as applied to land, is defined as "the act or process of restoring to cultivation or use." I should like to emphasize the words "or use" since this shows that reclamation can be accomplished by the preparing of land for a useful purpose, and this is not necessarily limited to cultivation, parks, or attempting the impossible task of restoring the land to its original condition. Another possible misconception I would like to correct is that this resulting use, after reclamation, is inferior to the

---

[*] The reports resulting from the University of Illinois research study are listed in the literature cited. They are Bauer [1965], Johnson [1966], and Jensen [1967]. Schellie and Rogier [1963] also refers to the subject of rehabilitation.

> original condition of the land. Very often this is not the case, and the end use may be more desirable than the virgin ground. Thus, in many of our crowded metropolitan areas a hole in the ground is worth more, economically and socially, than the original solid terrain.

Restoring a land to a previously planned condition is an integral part of the concept of multiple land use. This concept is twofold: (1) The same tract of land can be used for more than one purpose at a given time (Clawson, et. al. [1960], p. 36), and (2) over a period of time, land can serve more than one purpose. It is the latter concept which is important to reclamation of mineral deposits.

Depleted quarries are being used for a variety of purposes. In most cases, however, it was not decided until after the quarry terminated its operation what function the land would serve. A notable exception is the San Fernando Valley, California, where plans were made to quarry for sand and gravel, use the depleted quarry for the disposal of solid waste, and then to cover the area and construct a residential community (Goldman [1959]).

A well established reclamation plan can be a powerful weapon for allowing quarrying in metropolitan areas. In the future, the quarry operator will most likely be required to provide such plans before commencing his operation.

2.60 Urban Planning and Zoning

> City and town planning is a science, an art, and a movement of policy concerned with the shaping and guiding of the physical growth and arrangement of towns in harmony with their social and economic needs. We pursue it as a science to obtain knowledge of urban structure and services and the relation of its constituent parts and processes of circulation; as an art to determine the layout of the ground, the arrangement of land uses and ways of communication and the design of the buildings on principles that will secure order, health, and efficiency in development; and as a movement of policy to give effect to our principles (Haar [1959], p. 46).

In a Utopian situation the urban planning process might proceed as follows: individual specialists would forecast the needs of the community (its transportation, recreation, housing, etc. requirements). These specialists would then discuss as a group the interactions caused by their individual needs. As a result of the interactions, the individual requirements would then be altered. This process would continue until an overall, coordinated plan satisfying all specialists is formulated. This Master Plan would then dictate the growth of its community, using zoning ordinances to act as the legal method by which the Master Plan would be enforced. The plan would have to be dynamically flexible in order to be able to accept changes as the community grows.

In the real world, master plans are not developed in the above manner. Coordination and the reevaluation of specific areas is not as prevalent as it might be. Furthermore, it is the local towns, counties, etc. who develop the zoning ordinances. This policy tends to satisfy the demands of its local citizens, but very often at the expense of neighboring communities.

This research attempts to show how the coordination of planning and zoning on a larger scale can be beneficial to the community as a whole. The premise is that what is "best" for one might not be "best" for all.

Zoning ordinances are the legal means by which urban land usage is controlled. For the purpose of this research, the only zoning restrictions considered are those which allow or disallow removing naturally occurring material from the earth (quarrying), and processing of the material. The decisions are strictly binary (yes-no). The effect of zoning which limits the amount of production, by limiting, for example, the depth below the surface that the quarry operator can dig, can be studied by varying the quarry reserve on the input data cards. By varying the quality, quantity, and zoning laws, the effects of planned hygrading* can be investigated.

---

*Hygrading in the mineral industry means removing only higher quality material for immediate profits. To hygrade connotes waste. Planned hygrading is based on the assumption that if land is available for only a short time, it is better to remove some material than to let it all go to waste.

CHAPTER III

RESEARCH METHODOLOGY

3.10 Introduction

The system which describes the mineral aggregate industry and its relationship with the economy is highly complex. Connors and Teichroew ([1967], p. 93) suggest five methods for solving dynamic models, and rates them in order of decreasing desirability.

1) Analytic Techniques: The optimum solution can be expressed as a function of the state variables.
2) Iterative Algorithms: The optimum solution can be computed numerically, for any given values of the state variables, by a series of computations which proceed from one solution to a better one.
3) Search of All Alternatives: All feasible alternatives are enumerated, and the value of the objective functional is computed for each one.
4) Heuristic Techniques: A sequence of feasible alternatives is generated, and the best one is selected. However, there is no guarantee that a better one does not exist.
5) Simulation: The outcome of a decision is computed by following through a "model" of the process.

Solutions 1 and 2 presume a knowledge of the mathematical structure of the model. Solution 3 and 4 assume that all feasible alternatives are known. None of these cases applied to this research. Therefore, in order to learn more about the components of the system, a simulation model has been developed which will both aid in the analysis of the system and act as a predictive model for planning purposes.

Simulation, which is described in the following sections of this chapter, enables the researchers to study the effects of changing various parameters, variables, and decision processes included within the model. From the analysis of the sensitivity of the various components of the model, future research can be approached and conducted in an economical fashion.

A simulation model also enables its user (the planner, for example) to find out how the system can be expected to react to various planning schemes. It describes "what will happen if---?" rather than says, "the optimal strategy would be---." Using simulation combined with heuristic techniques, the "best" alternative can be selected.

3.20 Simulation - A General Description

Simulation involves the development of a mathematical or logical model (or combination of the two) which displays certain properties of the system which it is intended to describe. Shubik ([1960], p. 909) defines simulation as:

> A simulation of a system or an organism is the operation of a model or simulator which is a representation of the system or organism. The model is amenable to manipulations which

> would be impossible, too expensive or impractical to perform on the entity it portrays. The operation of the model can be studied and, from it, properties concerning the behavior of the actual system or its subsystem can be inferred.

Naylor, et al ([1966], p. 3) suggest that the usual interest is in models which simulate highly complex systems such as an industry or an economy; that the nature of the models is mathematical or logical, rather than physical; that the models are primarily developed for analysis on a digital computer; and that the systems which are simulated are time dependent - dynamic.

Under these assumptions, his restricted definition is:

> Simulation is a numerical technique for conducting experiments on a digital computer, which involves certain types of mathematical and logical models that describe the behavior of a business or economic system (or some component thereof) over extended periods of real time.

It is this definition to which this research refers when "simulation" is described or discussed.

Although simulation models have been classified in a number of ways, for this research the classification scheme suggested by Naylor has been chosen. Based on the time element involved, the model can be either static or dynamic. A static model is one where time is not a factor, or only one specific time period is being studied. The dynamic model is one which is time dependent - where the outcome during a given time period is a function of, or dependent on, what happened in previous time periods. The model developed in this research is, in fact, time dependent (we are simulating over time the demands on mineral resources) and is therefore classified as dynamic.

Models may also be classified as either deterministic or stochastic. The deterministic model is one in which all elements are known with complete certainty. For example, the life of a quarry is a given value, it is not a number whose value is expressed by a probability density function. Furthermore, all decision paths are taken with complete certainty; the model does not say for example, that "A" will go to "B" with a probability of 60% or to "C" with a probability of 40%. The stochastic model, on the other hand, has at least one element (an input value, decision branch, etc.) whose value is determined by a probability function (usually using some form of pseudo-random number generator.) The model developed in this research is deterministic. All input values are accepted as strictly determined values, and all decision branches are known with complete certainty. A discussion on adding probabilistic elements to the model is contained in Chapter VII, Section 7.20.

3.30 Simulation and Urban Problems

Even though the use of computer simulation models is a relatively new "problem solving" technique, it is rapidly being adopted for studying a variety of urban problems. The reasons for this trend are summarized by Wolfe and Ernst ([1967], p. 50).

> A combination of developments -- principally the computational capacity offered by digital computers, the acquisition of increasingly complete data on urban physical and population characteristics, and the development of improved understanding of the mechanisms at work that determine land use in urban areas -- has gradually led to a number of projects on which large-scale systems analysis, or model building, has been employed in an effort to simulate the operations and interactions of a mass of variables relevant to urban planning.

In "A Conceptual Framework for Urban Planning Models", Kilbridge, et. al. [1969] review the present day status of urban planning models and present a framework for their analysis. They analyze twenty urban planning models from the viewpoint of the subject of the model, its function, the theory upon which the model was constructed, and the methods employed by the model to achieve the stated function. They suggest that:

> Strictly speaking, simulation refers to the way in which a model is used rather than to the structure of the model itself. However, it is sometimes possible to distinguish simulation models from analytic models on the basis of mathematical structure. Analytic models contain precise mathematical statements which can be solved--at least theoretically--by standard mathematical operations. But simulation models usually include non-mathematical statements about relationships between elements which, though sufficiently clear for conversion to a computer program, have no mathematic "solution" (Kilbridge, et. al. [1969], p. B-259).

Included in this article is an annotated bibliography of the twenty models discussed and a general bibliography of urban models.

Further examples of problems where simulation techniques have been applied can be found in "Operations Research for Public Systems" (Morse and Bacon [1967], the published results of a 1966 Summer program at the Massachusetts Institute of Technology on "Operations Research for Public Affairs." Included in this publication are:

1) Overviews to simulation in urban planning,
2) Transportation and traffic control simulations,
3) A discussion on simulation in medical and hospital practices,
4) Excellent bibliographies on the applications of operations research to urban problems.

A highly detailed model describing the special organization of human activities within a metropolitan area has been constructed and tested on the City of Pittsburgh by Lowry [1964]. This model will allow planners to observe the effects of public decisions and to predict changes over time of such entities as employment, population growth, and transportation networks. A game-simulation has been developed by Duke [1964] which allows planners to investigate the effects of simultaneous decision making (by specialized teams) on a hypothetical city.

In order to simulate a complex urban system, massive amounts of data and/or information about the system must be known. Before the age of the modern, high speed digital computer, these data were not readily available. Through the computer, we now have the potential ability to analyze tremendously large amounts of data in relatively short periods of time. The data, however, is still not available, and the data which is available is not in a form which can be readily manipulated or analyzed. The published results of a 1967 Symposium on the Applications of Computers to the Problems of Urban Society (Socio-Economic Planning Sciences [1968]) shows the growing awareness of the applicability of the computer to urban problems. Articles in the journal discuss the problems of data collection and describe the need for urban data banks.

There is no doubt that the development of a computer simulation is a costly, time consuming endeavor, due in part to the unavailability of data. As urban data banks are established, it is the opinion of this researcher that simulation of urban problems will become widely used as a planning and problem solving aid.

3.40 Simulation and the Mineral Resources

Noticeably lacking in the planning models described above was the consideration of the allocation of mineral resources. This does not mean, however, that simulation techniques have not been applied to problems of resource management.

Watt [1964] discusses simulation models which have been applied to studying problems of inland fish flow in the State of Washington, the control of water resources, and pest control in Canadian forests. Hufschmidt and Fiering [1966] describe the organization, design, and results of a model for simulating a water resource system (specifically the Lehigh River Basin in Pennsylvania).

Simulation models are presently being used to analyze specific problems relating to mineral resources. Griffiths and Drew [1964] describe a model which aids in the exploration for oil and gas. Miesch, Connor, and Eicher [1964] describe how simulation can be used to aid in the sampling of the chemical properties of rocks. Nelson [1964] developed a simulation model which describes the characteristics, under various input situations, of a locomotive which is used for hauling materials from a mine. Our studies, however, have not found any simulation models which have been applied to aid in the planning of mineral resources.

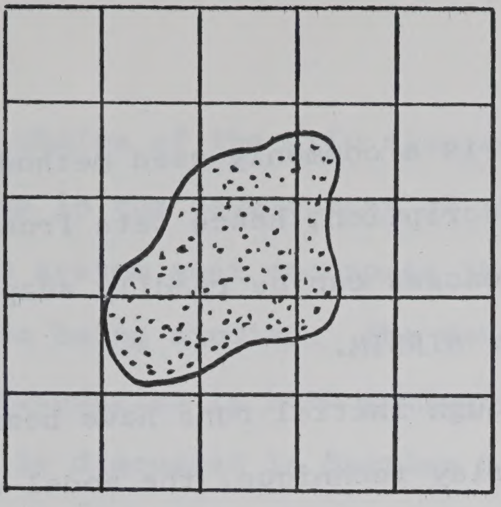
3.50 Specific Computer Simulation Techniques

This section describes the many decisions which were made prior to the development of MIRSIM (the MIneral Resource SImulation Model). It outlines the problems which are encountered when developing a model of this nature, the choice of computer language, and the question of program efficiency.

3.51 Model Formulation

The purpose of MIRSIM is to simulate over a time period the usage (and associated costs) of mineral aggregates in a geographic region. In order to accomplish this task it is necessary to describe all the variables, decision processes, and interactions between producers and consumers in a form which can be analyzed by a computer.

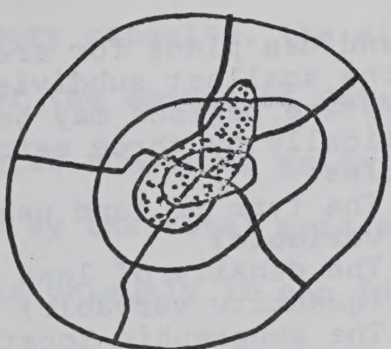
The first step is to describe the physical properties of the geographic area being studied. Two methods commonly being used are the grid overlay



GRID OVERLAY

FIGURE 3.1

and the ring and zone overlay which is commonly used for transportation models.



RING AND ZONE OVERLAY

FIGURE 3.2

This research has chosen to use the grid overlay technique for three reasons:

(1) The interest is in transportation distance between any two grids within the system, not just to and from center city,

(2) The use of the equal area grid facilitates computational techniques,

(3) It is a commonly used method of data description, hence data from outside agencies can be readily adapted as input for MIRSIM.

Even though initial runs have been made using only the grid overlay technique, the model can readily be adapted to use rings and zones by changing the subroutines which determine distances between points and the associated transportation costs (see Subroutines SRDIST & SRTRCST, Appendix B, Section B3.9 and B3.10).

Schlager ([1965], p. 106) describes very succinctly the development of a land use model:

> All land use plans for areas ranging from the smallest subdivision to multi-state regions may be expressed symbolically by three sets of variables:
>
> 1. The type of land use (quality variable)
> 2. The density of land use (quantity variable)
> 3. The geographic location (location variable)
>
> Typically, the land area concerned will be subdivided into a grid of "zones" of equal area. The location variable is determined by the geographic coordinates of the zone in question. For each zone, the types and densities of land uses may be expressed as a measure of the activities in that zonal area. The amount of detail provided will depend on the coarseness of the grid. For small areas, a zone may be as small as individual residential lot parcels. In large regions, they may be counties or even states. The key point to be observed is that all land use plans may be expressed by these three classes of variables.

The choice of the grid size and coverage was a critical step in the development of the computer model. The total grid system must encompass the entire geographic area being studied. The determination of the physical boundaries is both geologic and economic in nature and is discussed in Section 3.60. Once the boundaries are determined, the region enclosed by them is then divided into a number of rectangular grids of the same size. The size (or conversely the number) of the rectangular grids within the system must then be determined. If it is assumed that the computational facility which will analyze the simulation model has infinite core memory capacity, the size of the grid is only a function of the amount of detail required within each grid; the total number of grids is determined by the area enclosed by the total grid system. The larger the grid, the less uniquely it can identify the entities within it.

In actuality, computer memory is limited. Hence, the number of grids is physically constrained by core capacity (see Appendix B, Section B.3). The number of grids is also constrained by the time limitations and the ability of the model users to gather the tremendous amounts of data required. The point which must be made is that smaller grids (and hence more within the system boundary) will usually add realism to the simulation procedure at the expense of a costlier data collection process and a program whose execution time is slower because of the increased number of searches required.

3.52 Language and Model Efficiency

An important step in the construction of a computer simulation model is the choice of computer language (or languages) in which the model will be programmed. Five factors must be considered in the selection of the computer language:

1. The structure of the problem,
2. How the model will be used and who will use it,
3. The programmer's capabilities,
4. Programming time and budget requirements, and
5. Available compilation software.

Very general computer languages have been developed for handling a wide array of problems, and languages have been developed for specific problems. For example, FORTRAN and ALGOL are general purpose languages which are usually applied to problems of a scientific nature involving the solving of mathematical relationships. GPSS has been developed for analyzing scheduling and waiting line problems such as the job shop or the simulation of a computer installation. COBOL is for business data processing type applications, and so forth. The point that must be made is that the structure of the problem which is to be computerized provides an indication of the language which should be used.

The second consideration is who will use the program and for what purpose. Programs which are going to be used only a few times (or which are relatively short with respect to computational time) need not be efficient with respect to execution time. Programs which are going to be changed by their user should be written in a language which is understandable to that user. Programs which are going to be run on more than one computer should be written in a language which is widely implemented.

If the program is relatively large, the programmer must be extremely proficient in the chosen language. Since budget constraints very often limit the amount of time and effort which can be spent in the programming phase, the choice of language must be one which can complete the job under the given constraints. Finally, the language must be implemented on at least the primary computer facility.

MIRSIM is a simulation model with certain properties of a scientific type program. As such, FORTRAN and GPSS were initially investigated. GPSS was immediately ruled out since the structure of the mineral aggregate producer - consumer system is very different from problems whose structure is similar to the job shop. In 1966, a FORTRAN program was constructed and tested on a hypothetical city using a 10 x 10 grid overlay (Wallace, Dunn, and Bishko [1966]). Execution time was very slow (on the order of eight minutes for a 20 year time period). Further indications that FORTRAN was not the proper language arose when attempts to enlarge the grid system resulted in exceeding core memory capacity.

MIRSIM has been written to be used repetitively by planners. To be an effective planning tool it must be relatively inexpensive to operate. The planner will certainly be more willing to test various planning alternatives when a twenty year simulated computer run takes a matter of minutes, rather than hours. As such, program efficiency is a highly desired quality. In order to minimize execution time, the grid information should be stored in core, rather than on peripheral equipment such as tape or disc. Efficient use of core provides this capability. Naylor ([1966], p. 38) stated that:

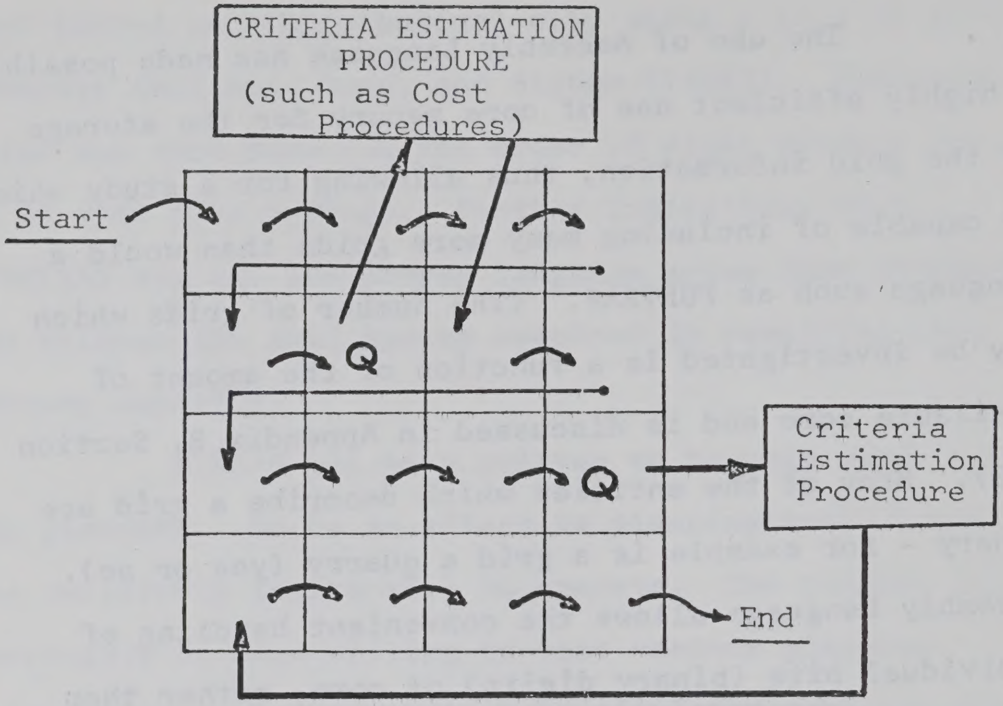
> Although we can reduce programming time by using a simulation language, we must usually pay a price for this benefit in terms of reduced flexibility in models and increased computer running times.

For these reasons, MIRSIM has been written in IBM/360 Assembly Language. This choice unfortunately restricts eventual model users to an IBM System/360 computing system and makes programming changes difficult.

3.53 Assembly Language Techniques

The use of Assembly Language has made possible a highly efficient use of core memory for the storage of the grid information, thus allowing for a study which is capable of including many more grids than would a language such as FORTRAN. (The number of grids which may be investigated is a function of the amount of available core and is discussed in Appendix B, Section B.3). Many of the entities which describe a grid are binary - for example is a grid a quarry (yes or no). Assembly Language allows the convenient handling of individual bits (binary digits) of core, rather than manipulation of words (32 bits on System/360) as would be done in FORTRAN. Furthermore, the decision processes, which constitute a very large programming section of the model, are in many cases binary.

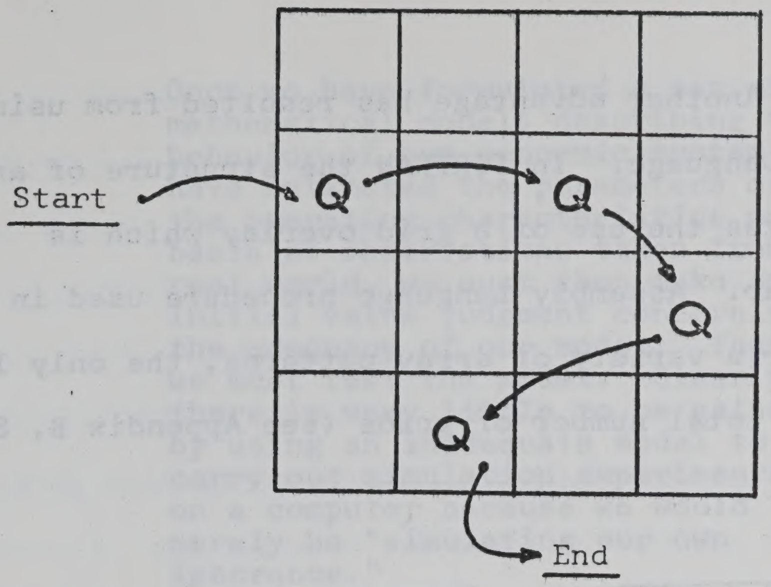
More important, during execution of the model, numerous searches of the grid system must be performed. For example, if a project needs to have a quarry assigned to it, all quarries are searched and the one which satisfies certain criteria picked. Using FORTRAN, these searches would be done using a DO loop, graphically portrayed as follows:


CRITERIA ESTIMATION PROCEDURE (such as Cost Procedures)
Start
Q
Q
Criteria Estimation Procedure
End

PICTORIAL REPRESENTATION OF SEARCH
PROCEDURE (FORTRAN)

FIGURE 3.3

From this example, it is obvious that all grids must be searched even though there might be only a few quarries in the entire grid system. Assembly Language makes possible chaining techniques whereby each quarry (for example) has associated with it the core address of the next quarry within the grid system. This search technique is pictured in Figure 3.4.

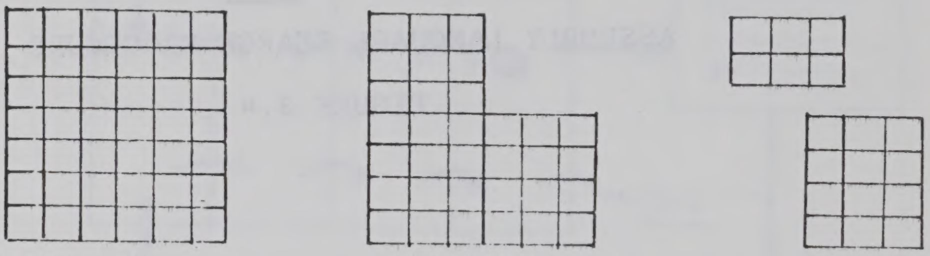


ASSEMBLY LANGUAGE SEARCH PROCEDURE

FIGURE 3.4

As a result of the dynamics of the model, it is often necessary to add or delete items from a chain. Addition of an item to a chain is a simple procedure. Since the order of items in a chain has no significance, new items will be added to the end of the existing chain. Problems, however, arise when it is desired to delete an item from a chain. The most efficient means of doing this is to both forward and backward chain all items. This means that not only should an item point to the next item in the chain, but it should also point to the one preceding it. Since this requires the use of an extra pointer (thus requiring more core space) this model forward chains only at the expense of a less efficient removal procedure.

Another advantage has resulted from using Assembly Language. In FORTRAN the structure of arrays necessitates the use of a grid overlay which is rectangular. Assembly Language procedure used in MIRSIM allows for a variety of array patterns, the only limit being the total number of grids (see Appendix B, Section B.3).



FORTRAN OF ASSEMBLY

ASSEMBLY

ASSEMBLY

EXAMPLE OF GRID OVERLAYS

FIGURE 3.5

3.60 Pilot Study

In order to test the feasibility of using simulation as a "problem solving" technique, and in order to test how well it responds as a real world simulator, it is necessary that the simulation model be run and tested with real data on a real problem.

> Once we have formulated a set of mathematical models describing the behavior of our economic system and have estimated the parameters of the operating characteristics on the basis of observations taken from the real world, we must then make an initial value judgment concerning the adequacy of our model. That is, we must test the model. Clearly, there is very little to be gained by using an inadequate model to carry out simulation experiments on a computer because we would merely be "simulating our own ignorance."
>
> This step of the simulation procedure merely represents the first stage of testing a simulation model prior to actual computer runs. At this point we are primarily interested in testing the assumptions or inputs that will be programmed into the computer (Naylor, et. al. [1966], p. 35).

Although MIRSIM has been constructed as a model which can be applied to studying any region in the country, it has specifically been constructed from knowledge and information gained in the Tri-City area (Albany, Troy, and Schenectady, New York). Using Tri-City area data as input to the model, program debugging and model validation have taken place. Results of real input parameter data have made possible sensitivity analyses which will act as guides for future studies. Furthermore, the types of data and actual problems of data collection have been well delineated using the Tri-City area as the pilot study area.

The Tri-City area was picked as the pilot study region for three reasons:

1) It is a typical metropolitan region whose quarry suppliers can be bounded by a convenient grid system,
2) The geology of the area is known,
3) Available data exists in the form of the Capital District Transportation Study (see below) and through various New York State offices in Albany,
4) Rensselaer Polytechnic Institute is located in the heart of the region, thus facilitating the data collection process.

3.61 Model Validation

Every author writing on the general subject of simulation, and every experimenter constructing or using a specific simulation model is faced with the problem of validation. Amstutz ([1967], p. 380) suggested five levels of validity: viability, stability, consistency, duplication of historical conditions, and prediction of future states. Baisuck, et. al. [1967] borrow from psychometricians and suggest four types of validity: predictive, concurrent, content, and construct. Hufschmidt and Fiering [1966] tailor their validity criterion to their specific water resource simulation. Others philosophically argue whether a simulation model can, in fact, be validated.

Rather than give a specific definition of validation, this researcher feels that validity procedures must be adapted to the specific problem being investigated. In theory, levels or types of validity no doubt exist. However, it is very often infeasible (or even impossible) to validate a model at each of the suggested levels, or to pass it through a number of validating tests. Furthermore, the costs of certain validating procedures is often prohibitive.

What must be emphatically stated, however, is that the analysis of only the simulated output is not sufficient. The input data and the model itself must also pass validating criteria. For purposes of this research, validation consisted of an evaluation of the quality of the input data (which included testing its accuracy and completeness), an assessment of the model itself, and an analysis of the computer generated output. These procedures are discussed in detail in Chapter VI.

3.62 Data Collection

The data collection process can be classified into two categories: supply and demand. (A detailed description of data requirements can be found in Appendix A.)

Data affecting the supply of mineral aggregates consists of a survey of all active producers and an identification and mapping of all potential supplies.

Difficulties arose (and no doubt will continue to do so) because quarry operators were reluctant to make known cost data and quarry reserve estimates. Unless the study area has been geologically surveyed in great detail, the location of potential supplies (and subsequent estimation of reserve amounts, quality, and ownership) can be very difficult to obtain.

Data concerning supplies may also be obtained through agencies such as sand and gravel and crushed stone associations (both state and national), geologic surveys, the United States Bureau of Mines, and others. These agencies should be screened before the actual data collection process begins to provide an awareness of existing data.

The avenues of approaching the collection of demand data are many. They all, however, require that a land use and transportation study of the area has been made. The output of the transportation study determines the methodology of forecasting material demands. In general, the transportation study will yield on the basis of small geographic units projections for residential and non-residential land usage, and population projections. These forecasts are then converted into first construction requirements and finally into mineral aggregate usage.

Specific methodology concerning conversion and processing of raw data into the form required by MIRSIM is discussed in Chapter V.

Rather than give a specific definition of validation, this researcher feels that validity procedures must be adapted to the specific problem being investigated. In theory, levels or types of validity no doubt exist. However, it is very often infeasible (or even impossible) to validate a model at each of the suggested levels, or to pass it through a number of validating tests. Furthermore, the costs of certain validating procedures is often prohibitive.

What must be emphatically stated, however, is that the analysis of only the simulated output is not sufficient. The input data and the model itself must also pass validating criteria. For purposes of this research, validation consisted of an evaluation of the quality of the input data (which included testing its accuracy and completeness), an assessment of the model itself, and an analysis of the computer generated output. These procedures are discussed in detail in Chapter VI.

3.62 Data Collection

The data collection process can be classified into two categories: supply and demand. (A detailed description of data requirements can be found in Appendix A.)

Data affecting the supply of mineral aggregates consists of a survey of all active producers and an identification and mapping of all potential supplies.

Difficulties arose (and no doubt will continue to do so) because quarry operators were reluctant to make known cost data and quarry reserve estimates. Unless the study area has been geologically surveyed in great detail, the location of potential supplies (and subsequent estimation of reserve amounts, quality, and ownership) can be very difficult to obtain.

Data concerning supplies may also be obtained through agencies such as sand and gravel and crushed stone associations (both state and national), geologic surveys, the United States Bureau of Mines, and others. These agencies should be screened before the actual data collection process begins to provide an awareness of existing data.

The avenues of approaching the collection of demand data are many. They all, however, require that a land use and transportation study of the area has been made. The output of the transportation study determines the methodology of forecasting material demands. In general, the transportation study will yield on the basis of small geographic units projections for residential and non-residential land usage, and population projections. These forecasts are then converted into first construction requirements and finally into mineral aggregate usage.

Specific methodology concerning conversion and processing of raw data into the form required by MIRSIM is discussed in Chapter V.

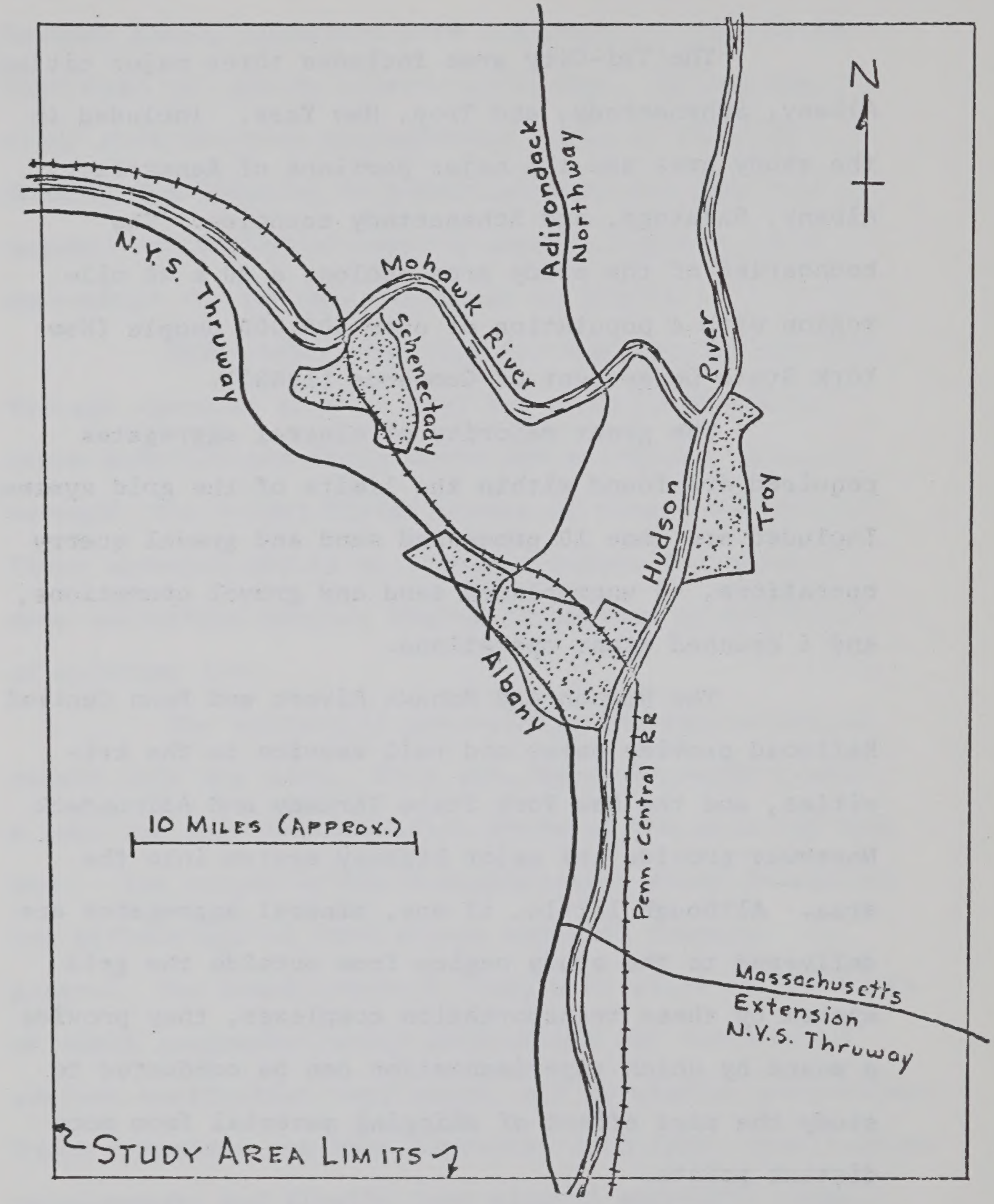
3.63 Pilot Study Area

The Tri-City area includes three major cities: Albany, Schenectady, and Troy, New York. Included in the study area are the major portions of Rensselaer, Albany, Saratoga, and Schenectady counties. The boundaries of the study area enclose a 30 x 40 mile region with a population of over 500,000 people (New York State Department of Commerce [1963]).

The great majority of mineral aggregates required are found within the limits of the grid system. Included are some 10 processed sand and gravel quarry operations, 40 unprocessed sand and gravel operations, and 5 crushed stone operations.

The Hudson and Mohawk Rivers and Penn Central Railroad provide water and rail service to the tri-cities, and the New York State Thruway and Adirondack Northway provide the major highway system into the area. Although little, if any, mineral aggregates are delivered to the study region from outside the grid system by these transportation complexes, they provide a means by which experimentation can be conducted to study the cost effect of shipping material from more distant points.

A simplified map of the Tri-City area is presented in Figure 3.6.



TRI-CITY AREA MAP

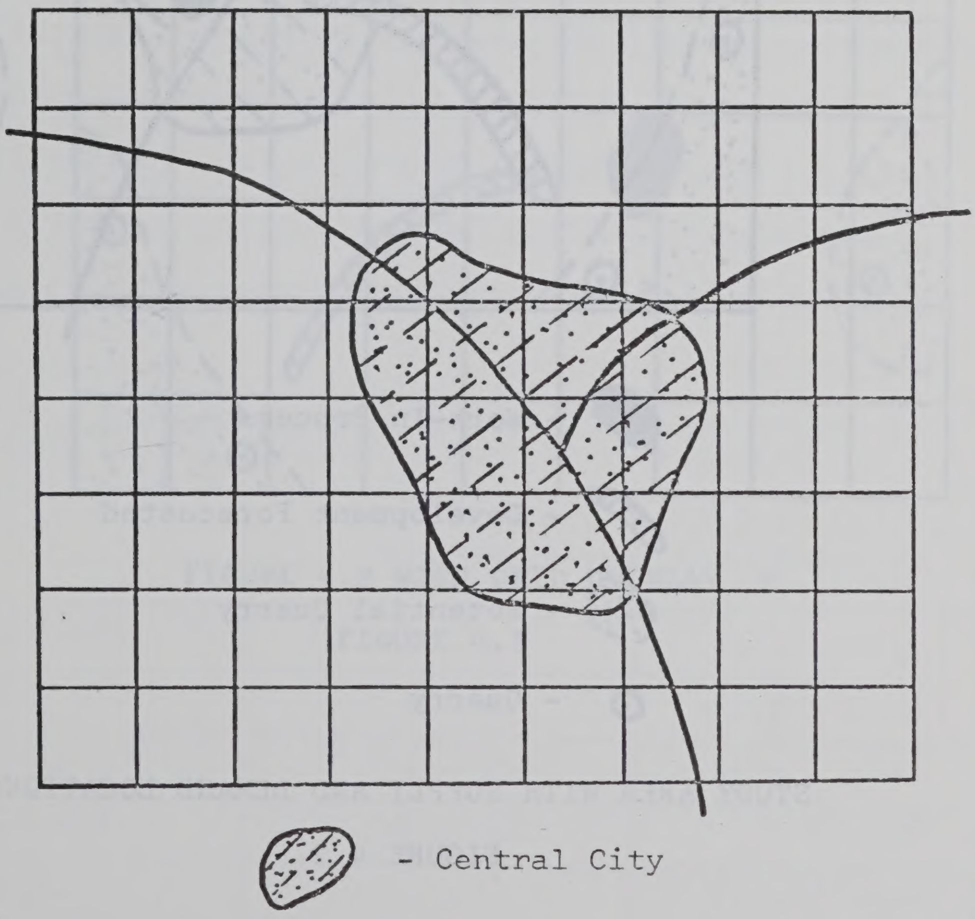
FIGURE 3.6

CHAPTER IV

MIRSIM (MINERAL RESOURCE SIMULATION MODEL)

4.10 General Description of the Simulation Process

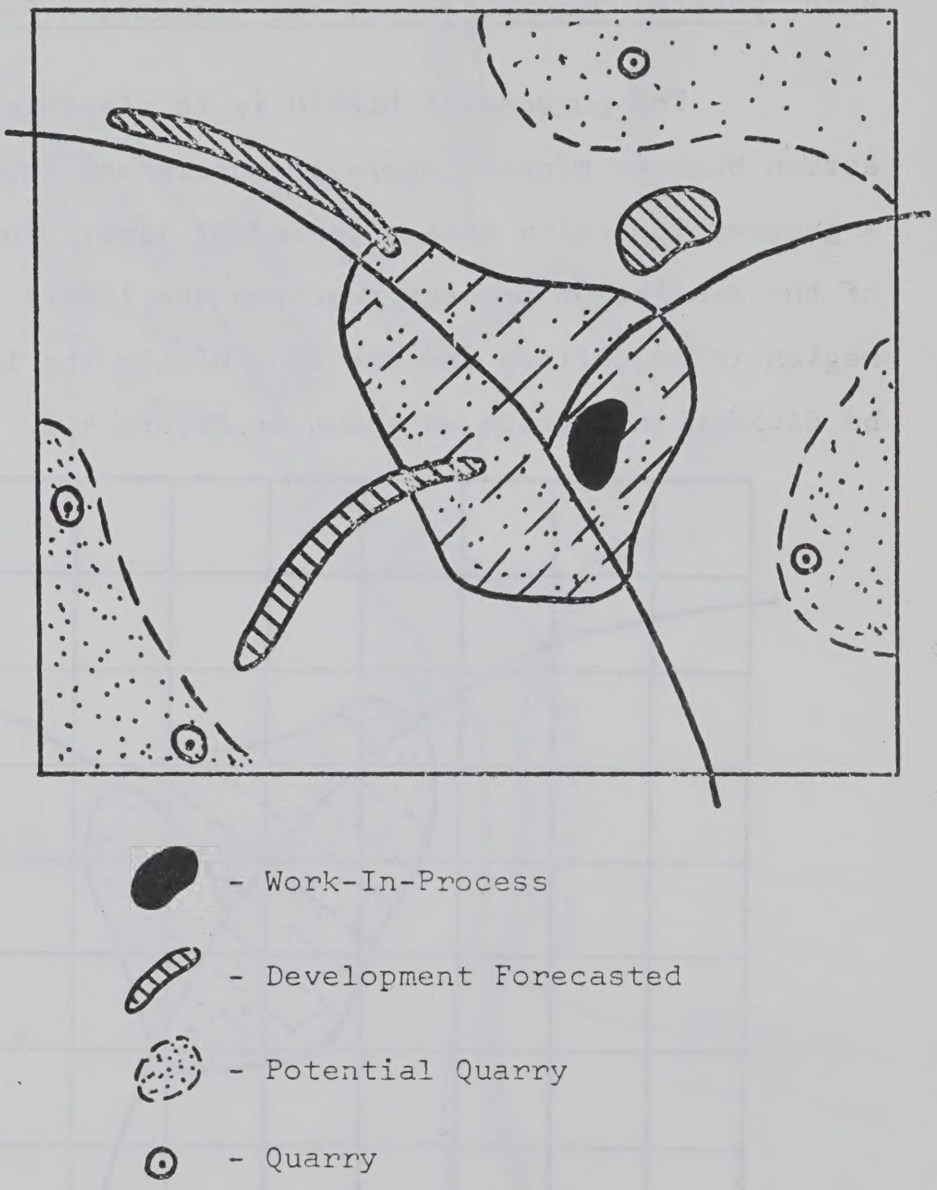
The purpose of MIRSIM is to simulate the interaction between mineral aggregate users and suppliers in a geographic region over a period of time. The nature of the simulation process requires the limits of the study region to be defined and the area within the limits to be divided into grids as shown in Figure 4.1.



EXAMPLE STUDY AREA WITH GRIDS

FIGURE 4.1

All quarries, potential quarries, developments forecasted, and works-in-process must then be identified on the study region map as shown in Figure 4.2.



STUDY AREA WITH SUPPLY AND DEMAND LOCATIONS

FIGURE 4.2

The grid overlay is then placed on the study region, and the characteristics of each grid identified and prepared for final analysis (Figure 4.3). The specific details of the input data are described in Chapter V and in Appendix A.

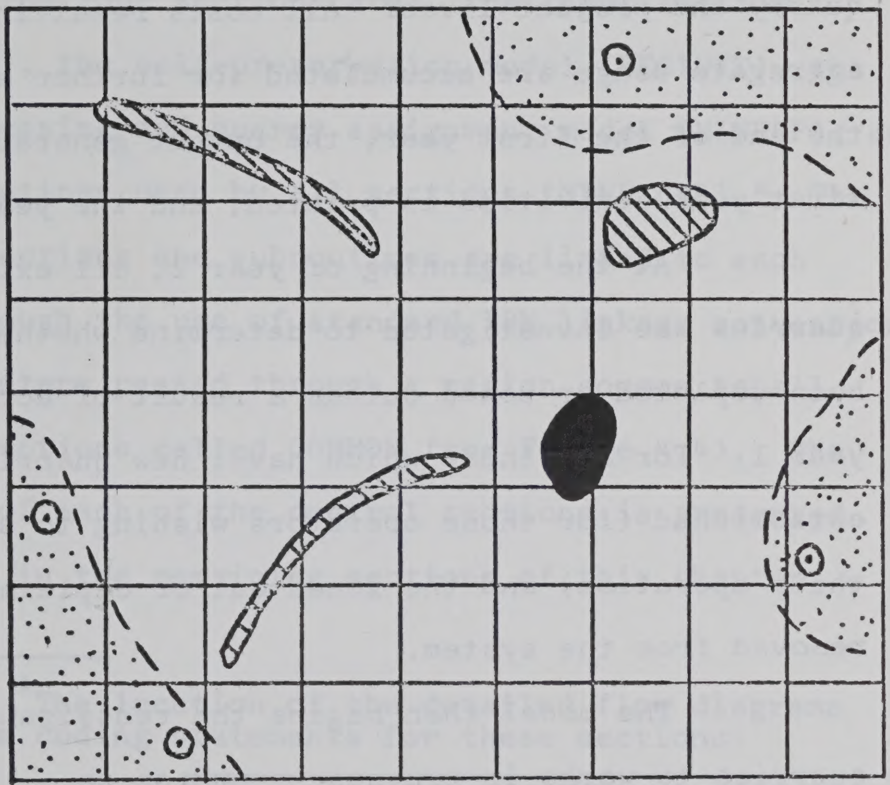


FIGURE 4.2 WITH GRID OVERLAY

FIGURE 4.3

The data are then punched onto tabulating cards (see Appendix A) for the computer simulation experiments.

The model begins its analysis in (simulated) year 1. It assigns quarries to all works-in-process and developments forecasted which are scheduled to begin during year 1 and simulates project development by updating quarry and project lives. All costs resulting from mineral aggregate usage are accumulated for further analysis. At the end of the first year, the output generated by the first year activities is printed, and the year updated.

At the beginning of year 2, all existing quarries are investigated to determine whether they have been depleted or zoned out as a result of activities in year 1. For all those which have, new quarries are established (for those operators wishing to self-preserve their operation) and the zoned out or depleted quarries removed from the system.

The model then begins the reassignment of quarries to works-in-process — and so on — throughout the simulated time period.

Although the above example is highly simplified, it provides the reader with a basic understanding of how MIRSIM operates. The details of the decision processes and of the program itself are provided in the remainder of this chapter.

4.20 General Overview of MIRSIM

For programming ease, MIRSIM is divided into four separate control sections, each of which carries on specific functions needed to accomplish the overall task of simulating mineral usage for a (simulated) time period. The four sections are: the input section (MINEINPT), the self-preservation model (BEGINIT), the data processing and quarry assignment model (MINEDP), and the subroutines used by all sections (MINESUBR).* The control sections and subroutines are linked to each other through the use of standard IBM linkage conventions, and parameters passed through a region common to all control sections called COMMON (see Figure 4.4). The function of each of the control sections is presented in detail in the remaining sections of this chapter.

---

*The location of the detailed flow diagrams and source coding statements for these sections:

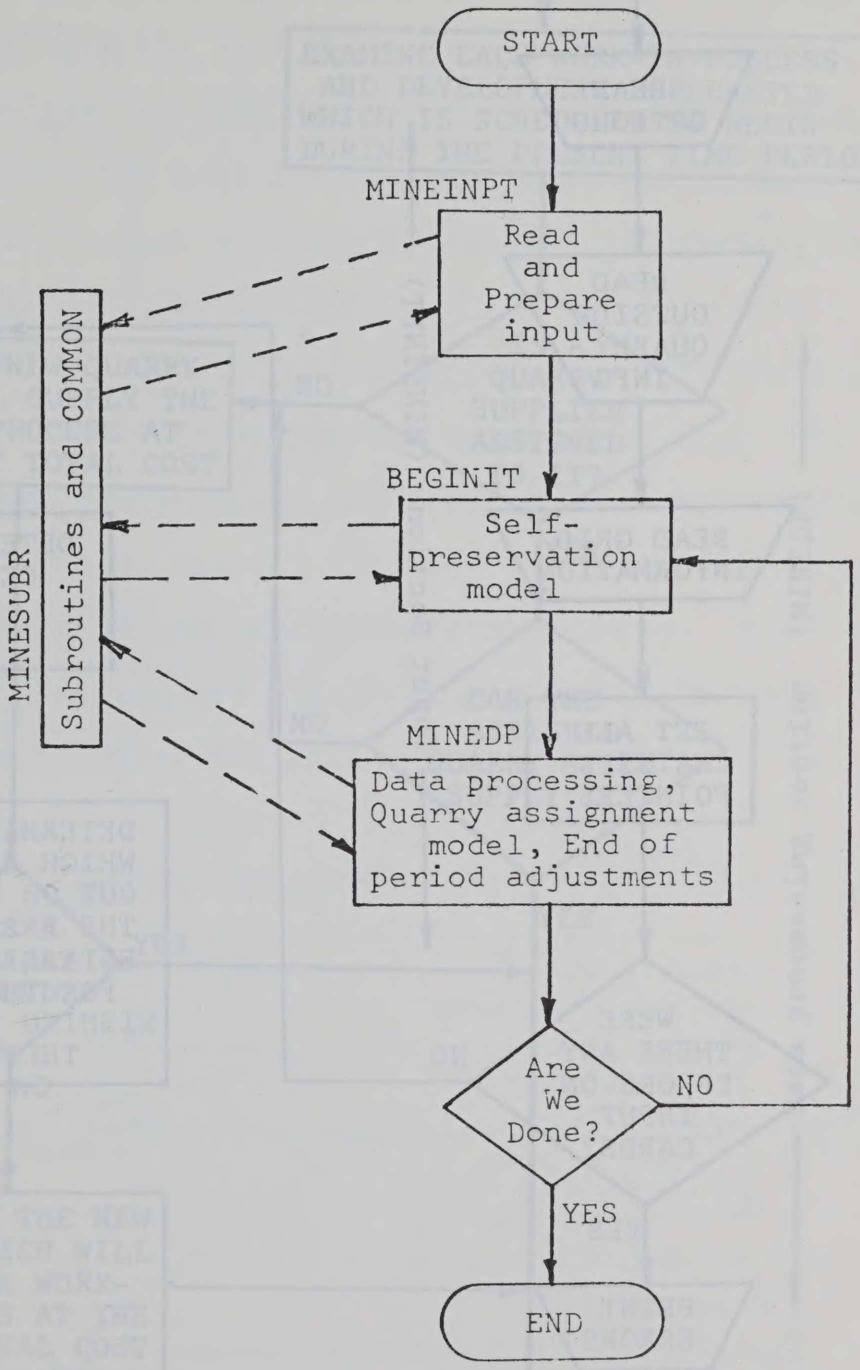
	Flow Diagram, Appendix C, pages	Source Coding, Appendix D, statements
MINEINPT	1 - 3	2811 - 3731
BEGINIT	4 - 8	848 - 1508
MINEDP	9 - 13	1510 - 2809
MINESUBR	14 - 20	1 - 846
COMMON	-	3733 - 3908

The general flow diagram of the entire simulation model is presented in Figure 4.5. This flow diagram describes in general terms the different functions performed by the simulation model without regard to the computing aspects encountered. The detailed set of flow diagrams is presented in Appendix C.

4.30 Input Control Section (MINEINPT)

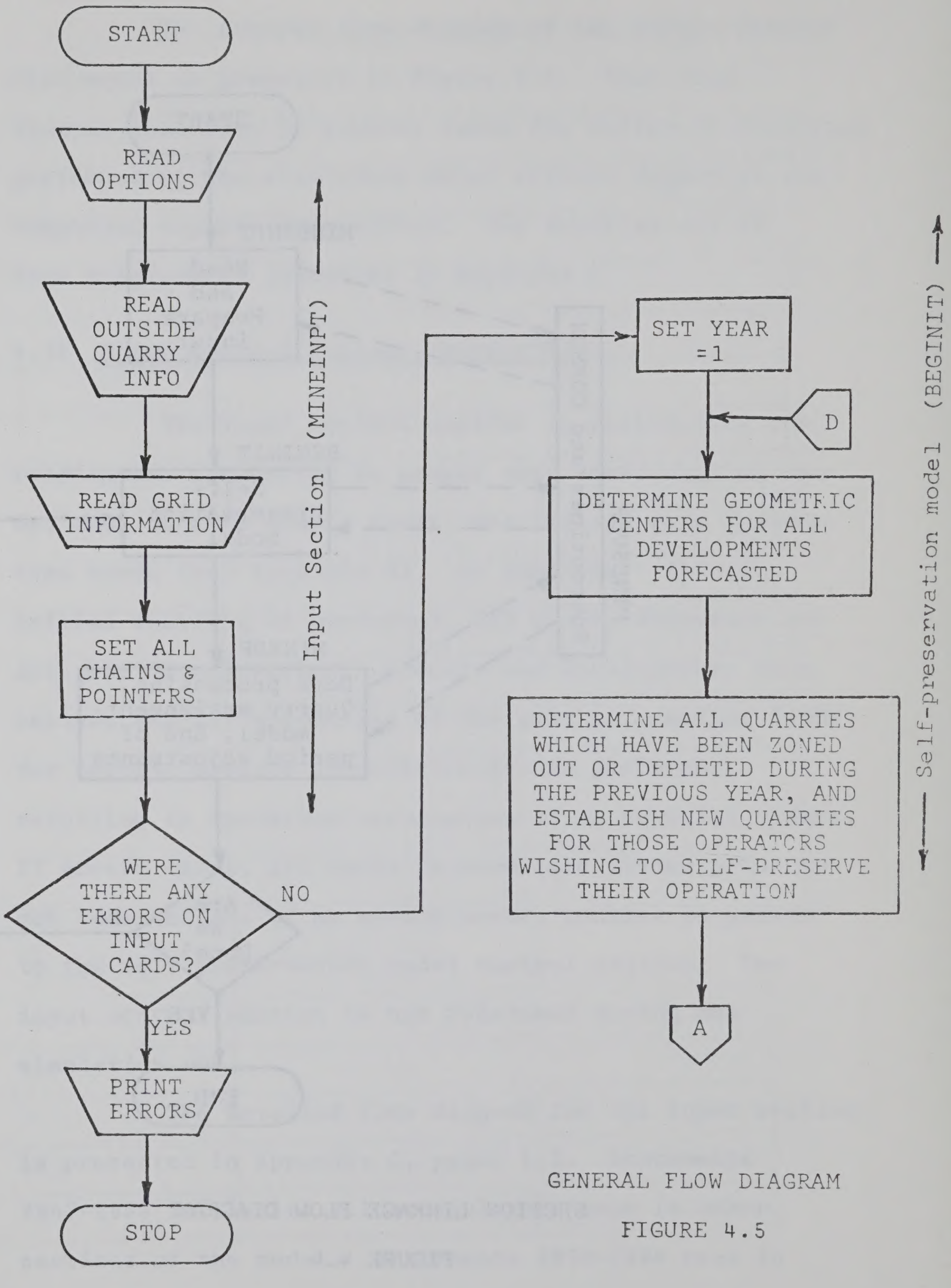
The input control section is responsible for reading and converting to proper core configuration the options, outside quarry cards, and initial grid information cards (see Appendix A). In addition: (1) all initial chaining is performed, (2) quarry addresses are assigned to all works-in-process and developments forecasted, and (3) a scanning of the grid information cards for certain obvious inconsistencies is performed, resulting in operation termination if an error(s) occurs. If errors exist, all cards in error are listed prior to job termination; if no errors occur, control is passed to the self-preservation model control section. The input control section is not reinvoked during the simulation run.

The detailed flow diagram for the input section is presented in Appendix C, pages 1-3. Statements 2847-2866 initialize all accumulators used in other sections of the model. Statements 2870-2984 read in the option cards and transportation cost curve (see



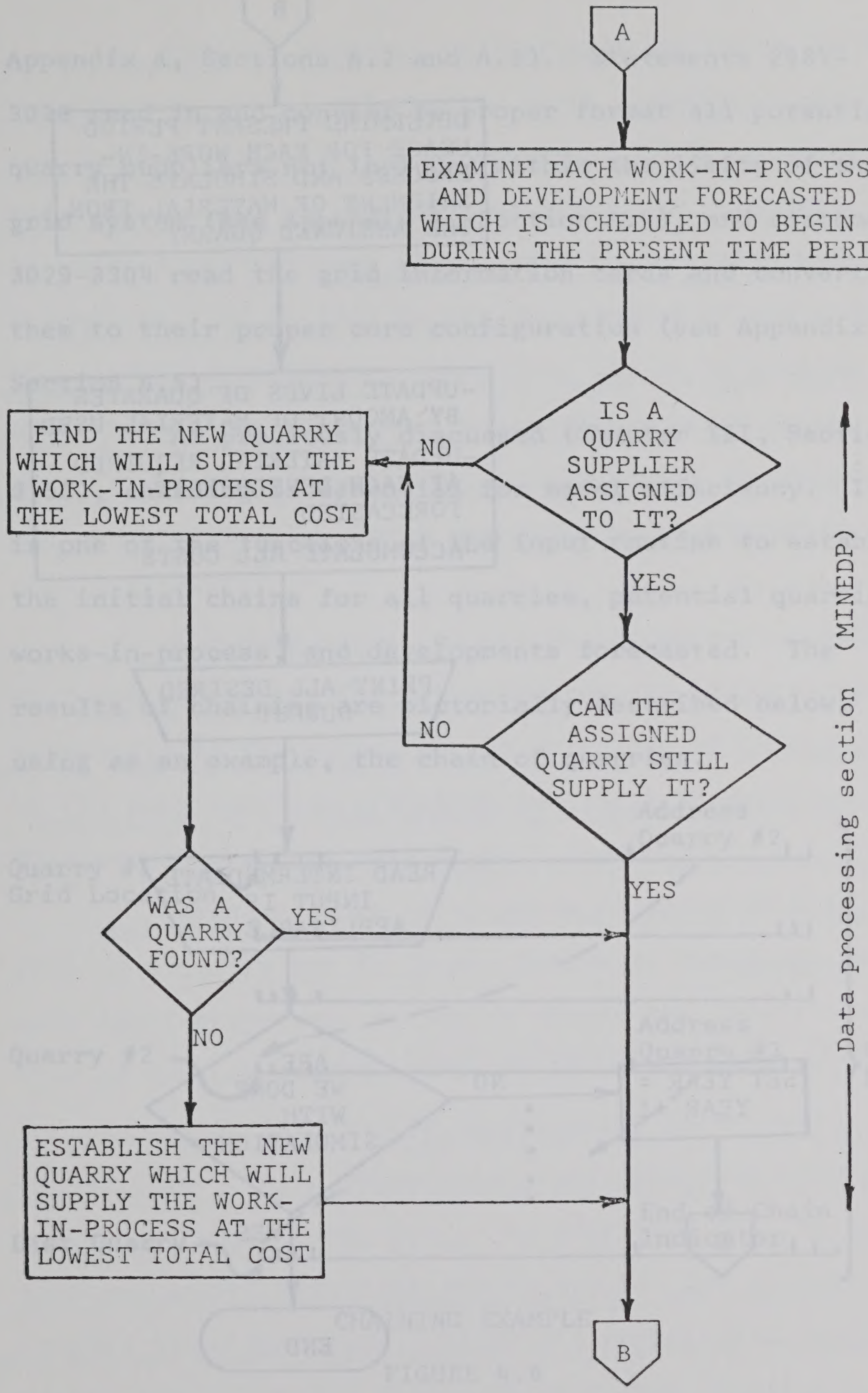
SECTION LINKAGE FLOW DIAGRAM

FIGURE 4.4


START
READ OPTIONS
READ OUTSIDE QUARRY INFO
READ GRID INFORMATION
SET ALL CHAINS & POINTERS
WERE THERE ANY ERRORS ON INPUT CARDS?
YES
PRINT ERRORS
STOP
NO
Input Section (MINEINPT)
SET YEAR =1
D
DETERMINE GEOMETRIC CENTERS FOR ALL DEVELOPMENTS FORECASTED
DETERMINE ALL QUARRIES WHICH HAVE BEEN ZONED OUT OR DEPLETED DURING THE PREVIOUS YEAR, AND ESTABLISH NEW QUARRIES FOR THOSE OPERATORS WISHING TO SELF-PRESERVE THEIR OPERATION
A
Self-preservation model (BEGINIT)

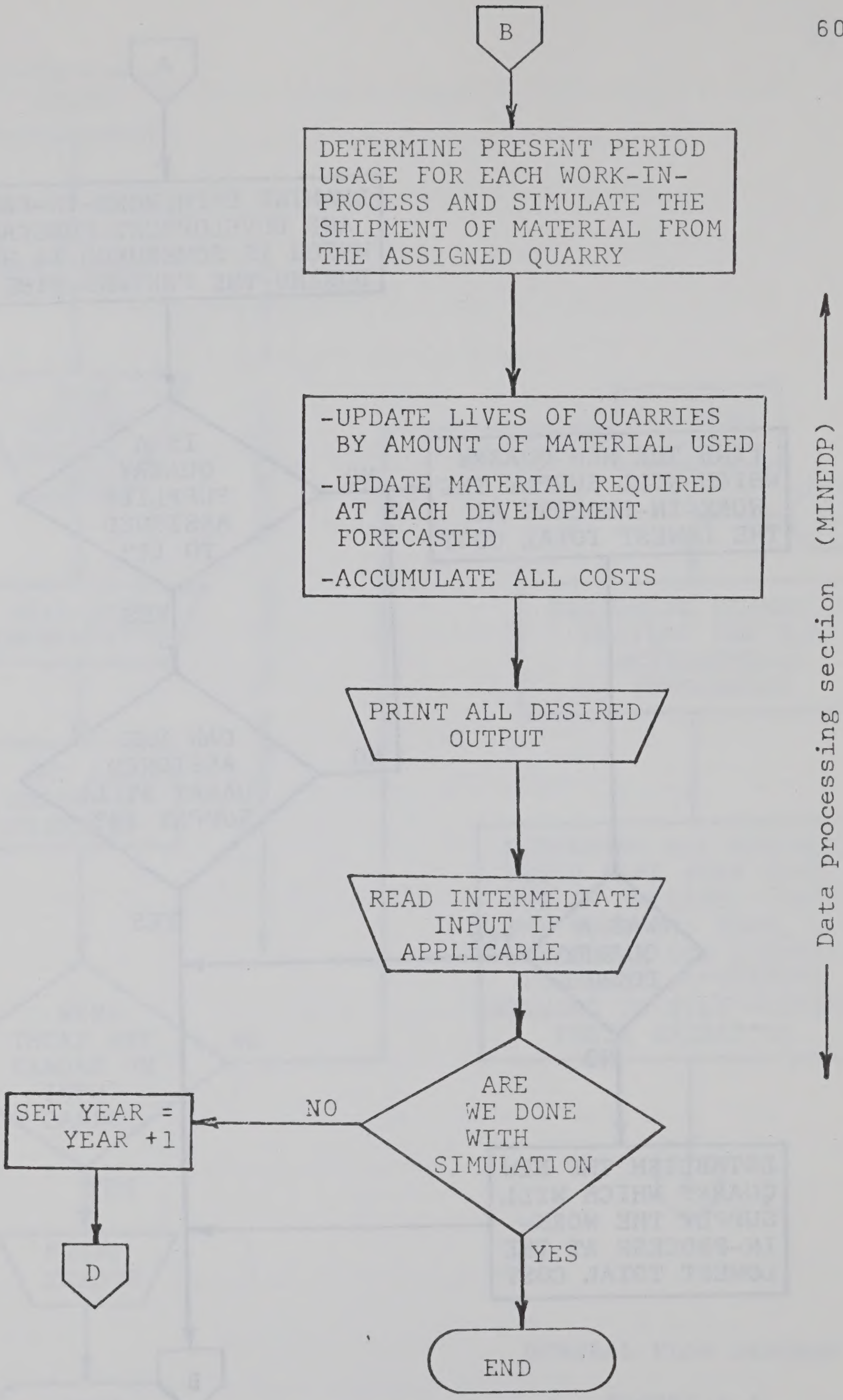
GENERAL FLOW DIAGRAM

FIGURE 4.5


A
EXAMINE EACH WORK-IN-PROCESS AND DEVELOPMENT FORECASTED WHICH IS SCHEDULED TO BEGIN DURING THE PRESENT TIME PERIOD
IS A QUARRY SUPPLIER ASSIGNED TO IT?
NO
FIND THE NEW QUARRY WHICH WILL SUPPLY THE WORK-IN-PROCESS AT THE LOWEST TOTAL COST
YES
CAN THE ASSIGNED QUARRY STILL SUPPLY IT?
NO
YES
WAS A QUARRY FOUND?
YES
NO
ESTABLISH THE NEW QUARRY WHICH WILL SUPPLY THE WORK-IN-PROCESS AT THE LOWEST TOTAL COST
B
Data processing section (MINEDP)

GENERAL FLOW DIAGRAM

FIGURE 4.5
(continued)

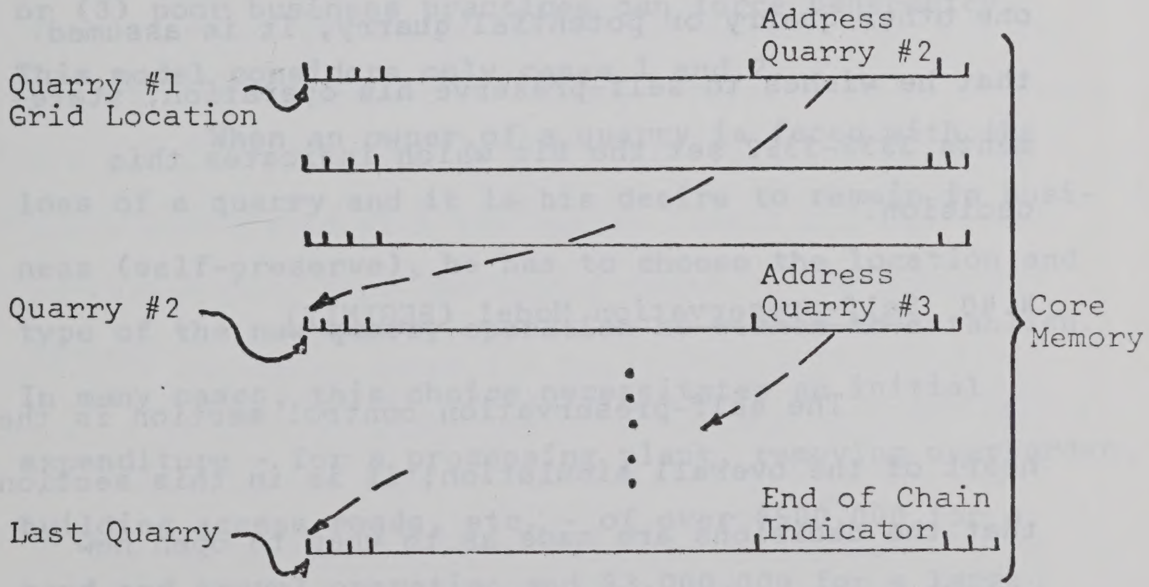

B
DETERMINE PRESENT PERIOD USAGE FOR EACH WORK-IN-PROCESS AND SIMULATE THE SHIPMENT OF MATERIAL FROM THE ASSIGNED QUARRY
-UPDATE LIVES OF QUARRIES BY AMOUNT OF MATERIAL USED
-UPDATE MATERIAL REQUIRED AT EACH DEVELOPMENT FORECASTED
-ACCUMULATE ALL COSTS
PRINT ALL DESIRED OUTPUT
READ INTERMEDIATE INPUT IF APPLICABLE
ARE WE DONE WITH SIMULATION
NO
SET YEAR = YEAR +1
D
YES
END
Data processing section (MINEDP)

GENERAL FLOW DIAGRAM

FIGURE 4.5
(continued)

Appendix A, Sections A.2 and A.3). Statements 2987-3028 read in and convert to proper format all potential quarry suppliers not included within the limits of the grid system (see Appendix A, Section A.4), and statements 3029-3304 read the grid information cards and convert them to their proper core configuration (see Appendix A, Section A.5).

As previously discussed (Chapter III, Section 3.53), chaining is essential for model efficiency. It is one of the functions of the input routine to establish the initial chains for all quarries, potential quarries, works-in-process, and developments forecasted. The results of chaining are pictorially described below, using as an example, the chain of quarries.



CHAINING EXAMPLE

FIGURE 4.6

Also set up by the chaining section are the core addresses of the first and last items in the chain. These addresses facilitate the search procedure and make the addition of new items to a chain very efficient from a computational standpoint.

If it is known that a certain quarry is supplying a work-in-process (or will supply a forecasted development), the input section (statements 3353-3489) replaces the row and column of the quarry supplier (which are read in as input) with the core address of the location of the specified quarry.

Finally, the input section is responsible for determining which quarry operators desire to self-preserve their operations. If an operator owns at least one other quarry or potential quarry, it is assumed that he wishes to self-preserve his operation; statements 3333-3352 set the bit which indicates this decision.

4.40 Self-preservation Model (BEGINIT)

The self-preservation control section is the heart of the overall simulation; it is in this section that the decisions are made as to when to open new quarries, the types of quarries that are to be opened, and, if alternative locations exist, where the new quarry should be established.

Through personal contact with operators in both the sand and gravel and crushed stone industries, state and federal officials, U. S. Bureau of Mines personnel, and academicians the decision alternatives have been delineated and the form of the self-preservation model determined. As is true in the development of any simulation model, simplifying assumptions had to be made in order to convert the actual decision procedure to one which could be mathematically and logically described in the computer model. These assumptions are discussed whenever applicable.

A quarry operation may be forced out of existence in three ways: (1) The active quarry can be physically depleted, (2) the quarry can be zoned out of existence, or (3) poor business practices can force bankruptcy. This model considers only cases 1 and 2.

When an owner of a quarry is faced with the loss of a quarry and it is his desire to remain in business (self-preserve), he has to choose the location and type of the new quarry operation he wishes to establish. In many cases, this choice necessitates an initial expenditure - for a processing plant, removing overburden, building access roads, etc. - of over $500,000 for a sand and gravel operation and $3,000,000 for a large crushed stone operation. Since his competitive position within the industrial framework is highly location oriented, the alternatives which the operator must consider are numerous.

If an operator desires to self-preserve, he can choose his new quarry from those properties directly owned by him, or available to him.* It is assumed in all self-preservation cases which follow that these are the only choices available to the owner of the zoned out or depleted quarry.

4.41 The Buyers' Influence on Quarry Location

Although in reality there can be other factors, in MIRSIM it is assumed that the purchaser of mineral aggregates will choose as his supplier whichever one is able to supply the required quality material** at the lowest total cost (including transportation cost). For example, New York State construction jobs are bid upon, and the lowest cost supplier is chosen.

Therefore, in this model, all decisions concerning the establishment of new quarries are based on which quarry location will be most competitive, i.e.

---

*In the data collection process, it is very difficult to establish in all cases ownership of potential quarries. In those cases where ownership is unknown, the land is made available to any operator wishing to self-preserve.

**When a certain quality material is required at a construction project, that quality or any better quality can be used. For example, using New York State quality specifications, if an C quality stone is required, an A, B, or C quality stone may be used.

which will be able to supply material at the lowest possible cost. In reality, the quarry operator who is faced with choosing a quarry site from among a set of alternative sites estimates which of these sites will be most competitive. This estimation procedure consists of his evaluating the potential market pattern and choosing whichever site will supply his estimation of the future market at the most competitive price. In MIRSIM, the future market demand pattern is determined by finding the weighted geometric center of future demand (see Section 4.45).

4.42 Cost Determination

As discussed in the previous section, costs from quarries to demand points are established and the lowest cost alternatives chosen. Three classes of costs are considered by the model: the fixed and variable costs associated with the quarry itself and the transportation cost from the supply point to the points of demand.

The fixed cost consists of four elements: 1) the depreciation cost of the initial processing plant, 2) the costs associated with preparing the quarry for operation (such as removing overburden and establishing access roads), 3) the cost of the land itself, and 4) the costs of land rehabilitation. For the one-quarry operation, the fixed cost per ton which is reflected in the selling price of the material is determined by dividing the total fixed cost (less allowances - see Section 4.43) by the estimated life of the quarry. In the multiquarry operation where one quarry is acting as a processing plant for at least one other quarry the fixed cost per ton is determined by dividing the fixed cost of the processing quarry by the sum of the lives of all the quarries using the intermediate processing plant.

The variable costs are the costs associated with mining and processing the aggregates, the cost of the aggregates themselves, and profits to the quarry owner. Quarry operators are, however, very reluctant to make known these costs. Since a breakdown of fixed and variable costs is necessary on the input data cards (see Appendix A, Section A.5), the model user must usually estimate them. As a check on the accuracy of the estimated costs, the sum of the fixed and variable cost should reflect the cost per ton charged by the quarry, F.O.B. the quarry itself.

Transportation cost is the cost per ton to move material (at a carload rate) over a fixed distance. This cost (which includes loading and unloading costs) is read in as data. Its format is discussed in Appendix A, Section A.3.

4.43 The Processing Plant

The largest portion of the initial investment for processed sand and gravel quarries and crushed stone quarries is the processing plant. The normal expected life of a new plant varies from 15 to 25 years under normal quarry output conditions.

For existing quarries which have processing plants, the input data must supply the estimated remaining life (in years) of the existing plant (see Appendix A, Section A.2). When, as a result of elapsed simulated time, the remaining life becomes zero, the model simulates the purchase of a new plant by setting its life equal to that of a new plant. The life of a new plant is set by the user as one of the options (see Appendix A, Section A.2). Also, when a new plant is established at a new site, its life is set to the value of the life of a new plant.

4.44 Allowance on Existing Processing Plants

In all decisions involving the possible termination of one processing type operation and the commencement of another, the cost of building a new processing plant is adjusted by an allowance on the old plant. In real terms, the allowance can be in the form of the ability to move the existing plants (or parts thereof) to the new location, or to sell the existing plant. This allowance, which is a function of the age of the old plant, is tabulated below. It must be noted that when a quarry is physically depleted, the allowance is set to zero since it is assumed that an owner will not purchase a plant whose economic life will exceed the expected life of the quarry

Age	% Savings (based on the cost to establish a new plant)
⩾ 15 years	70%
10 - 14 years	60%
5 - 9 years	40%
< 5 years	30%

PROCESSING PLANT ALLOWANCES

TABLE 4.1

4.45 Center of Demand Activity

As previously discussed, it is assumed that in the case where an operator has only one active quarry, each operator will, when the choice exists, choose the location at which he can be most competitive. MIRSIM simulates this choice by picking the quarry location which will supply the weighted geometric center (WGC) of demand activity within the planning horizon at the lowest total cost. The determination of the weighted geometric center of demand is as follows:

$$R_i = \frac{\sum_{j=1}^{n} (A_{i,j} \bullet r_j \bullet \delta_j)}{\sum_{j=1}^{n} (A_{i,j} \bullet \delta_j)}\text{, and}$$

$$C_i' = \frac{\sum_{j=1}^{n} (A_{i,j} \bullet c_j \bullet \delta_j)}{\sum_{j=1}^{n} (A_{i,j} \bullet \delta_j)};$$

where:

R_i = Row WGC for material i,

C_i = Column WGC for material i,

$A_{i,j}$ = Tons material i required by the development forecasted j (DEVFO_j),

r_j = Row DEVFO_j,

c_j = Column DEVFO_j,

$$i = \begin{cases} 1 = \text{Processed S\&G} \\ 2 = \text{Unprocessed S\&G} \\ 3 = \text{Crushed stone,} \end{cases}$$

j = 1,2,...,n, = development forecasted, and

$$\delta_j = \begin{cases} 0 \text{ if } \text{DEVFO}_j \text{ does not start within planning horizon} \\ 1 \text{ if } \text{DEVFO}_j \text{ does start within planning horizon.} \end{cases}$$

As described above, the row and column of the weighted geometric center for material "i" is the first moment about row 0 and column 0 of all developments forecasted scheduled to begin within the planning horizon. The planning horizon is that length of time in the future within which a quarry operator will look to determine the demand pattern facing his operation. Although this period of time can be set to any value by the model user (see Appendix A, Section A.2), the simulation runs described in Chapter VI used a five year planning horizon.

In the case where the operator has more than one active quarry, it is assumed that he is actively engaged in attaining business from more than one sector. His choice of a new quarry site will be that quarry which will supply the quarry zoned out (rather than the weighted geometric center) at the lowest total cost. This prevents the possible establishment of two active quarries within the same general area, and thus spreads the scope of influence of the operator.

4.46 The Processed Sand and Gravel Operation

The self-preservation procedure for the processed sand and gravel operator is modeled in two major sections, the single quarry operation and the multi-quarry operation. Because the ability to quarry material at one quarry site (physically remove it from the ground) and ship it to another quarry (intermediate point) for processing is unique to the processed sand and gravel industry, the decision alternatives the processed sand and gravel operator is faced with are greater in number than those of the unprocessed sand gravel operator or the crushed stone operator.

In the case of the single quarry whose operation is terminated by either zoning restriction or physical depletion, the owner who does not own potential quarry land is forced out of business. The decisions confronting the owner who wishes to self-preserve are a function of the cause of operation termination and are discussed below.

If the quarry is depleted or zoned out (in either case removing material from the earth must cease) but processing can continue, the operator has two alternatives. He can (1) open an entirely new operation at that new site which is capable of supplying the weighted geometric center of processed sand and gravel at the lowest cost or (2) continue processing at the depleted quarry, shipping material from that new quarry whose total cost (cost to mine and process at new site + transportation cost to intermediate point + transportation cost from the intermediate point to the weighted geometric center of processed sand and gravel) is lowest. The decision between these two alternatives is to choose that alternative which will supply material to the weighted geometric center at the lowest total cost. It must be noted that even though the assumption has been made that a processing plant has no economic worth at a quarry which is depleted, the plant can (and in real life will) continue to operate.

For example, assume that quarry "X" is either depleted or zoned out (but processing can continue), and the owner of quarry "X" has three potential supply areas, "A", "B", & "C", whose cost alternatives are shown below.

from	Potential Quarry		
to	A	B	C
Weighted geometric center (building a processing plant at the new site)	$2.10	$2.20	$2.30
To quarry "X" for processing and then WGC	$2.30	$2.00	$2.50

SINGLE QUARRY OPERATION DECISION EXAMPLE

TABLE 4.2

The owner of quarry "X" would establish potential quarry "B", using quarry "X" as an intermediate point.

In the case that the quarry is zoned out (i.e. removing material from the quarry must cease) and processing cannot continue, the operator has only one choice: to open that new quarry (with a processing plant at the new site) which will supply the weighted geometric center of processed sand and gravel demand at the lowest total cost. The cost of the new processing plant is adjusted by the allowance on the existing processing plant before the fixed portion of the total cost is determined. For example, referring to the data in Table 4.2, quarry "X" cannot be used for processing;

the owner would therefore establish potential quarry "A" as a quarry with a processing plant at it.

In the multi-quarry sand and gravel operation, the alternatives are greater in number (see flow diagram, Appendix C, page 6). The zoned out or depleted processed sand and gravel quarry can be (1) a quarry with a processing plant which processes its own material but does not act as an intermediate point, (2) a quarry with a processing plant which is acting as an intermediate point, or (3) a quarry which is not a processing plant but which transports its sand and gravel to another point for processing. These three cases are discussed below.

In case 1 - the processing plant which processes only its own material - the decisions are similar to the one plant operation with the exception that the focal point of demand is not the weighted geometric center but is the quarry which was zoned out or depleted. If the quarry is depleted or zoned out and processing can continue, the two alternatives the operator is faced with are to open an entirely new operation - which includes a processing plant at the new site - or to open a new quarry, using the zoned out or depleted quarry as an intermediate point. Whichever of these two alternatives will provide material at the lowest cost will be chosen. If, however, the zoning law does not allow processing to continue, the ability to use the zoned out quarry as an intermediate point is eliminated.

Competitive cost for the establishment of a new quarry and processing plant is determined by adding the fixed costs, variable costs, and the transportation cost from the new site to the site of the zoned out or depleted quarry. The cost of the establishment of a new quarry using the zoned out or depleted quarry as an intermediate point is determined by adding the fixed costs associated with the existing quarry, the variable costs at the new quarry, the transportation cost from the new quarry to the old quarry (which is a processing plant) and from the old quarry to the weighted geometric center of demand activity. If alternative quarry locations exist, whichever one will provide material at the lowest total cost is chosen.

For example, quarry "X", which processes its own material but does not act as an intermediate point, is either depleted or zoned out but processing can continue. The owner of quarry "X" owns other active quarries and potential quarries "A", "B", and "C". His decision alternatives and example costs are tabulated below.

to \ from	Potential Quarry		
	A	B	C
Quarry "X" (building a processing plant at the new site)	$2.30	$2.15	$2.20
To quarry "X" for processing and then to weighted geometric center	$2.10	$2.20	$2.25

MULTI-QUARRY OPERATION DECISION EXAMPLE

TABLE 4.3

His solution would be to establish potential quarry "A" as a quarry without a processing plant and transport its material to quarry "X" for processing.

If, however, processing could not continue at quarry "X", he would establish potential quarry "B" as a quarry with a processing plant at the site.

In case 2 - the zoned out or depleted quarry is being used as an intermediate point - the alternatives are quite different from those discussed above. If the quarry is depleted and processing can continue at the zoned out quarry, it is assumed that no action will be taken by the operator since the quarries' function of providing processing for other quarries has not been hindred. If, however, zoning prohibits processing from continuing, the operator is faced with the immediate problem of establishing a processing plant which will act as an intermediate point for the one or more quarries using the zoned out processing plant. If only one quarry was using the zoned out quarry for processing, a processing plant will be opened at that site. Amortization cost at the new site will be determined by dividing the cost of the new processing plant (less allowances) by the remaining life of the quarry.

If more than one quarry is using the zoned out quarry for processing, that quarry closest to the weighted geometric center of processed sand and gravel will be established as an intermediate point. The rationale behind choosing as an intermediate point the one closest to the weighed geometric is that, in reality, it places the production facilities (and therefore stockpiling capabilities) closest to the center of demand. Amortization cost at that site will be determined by dividing the establishment cost (less allowances on the existing plant) by the sum of the remaining lives of all the quarries using the intermediate point.

For example, quarry "X" is being used as an intermediate processing point for quarries A, B, C, and quarry "X" is zoned out. If processing is allowed to continue, no action will be taken. If processing is not allowed to continue, the owner of quarry "X" will establish a processing plant at whichever quarry (A, B, or C) is closest to the weighted geometric center of demand.

The third case is that the zoned out or depleted quarry is producing processed sand and gravel but shipping to another point for processing. Since the operator is faced with the situation of at least one processing plant at another site and a reduced amount of material to supply it, he will, if possible, establish a new quarry to supply the intermediate point. The choice of a new quarry is that quarry which will supply the existing processing plant at the lowest cost, or, in the situation where more than one quarry which is serving as an intermediate processing plant, that quarry which will supply the processing plant closest to the weighted geometric center at the lowest cost.

For example, the owner of zoned out quarry "X", which is producing processed sand and gravel and shipping to another quarry for processing also owns potential quarries "A", "B", and "C", and quarries "Y", and "Z", each of which is acting as intermediate processing points. The owner will establish as a new quarry whichever potential quarry (A, B, or C) is capable of supplying material at the lowest cost to the quarry which is closest to the weighted geometric center of demand (i.e. Y or Z).

In all cases, it is assumed that only as a last alternative will the processed sand and gravel operator go into an unprocessed operation. This will be necessitated if all lands owned by him (or to which he has access) contain only a low quality material.

4.47 The Unprocessed Sand and Gravel Operation

The unprocessed sand and gravel operation is characterized by a low quality, usually non-State approved, run of bank material. The actual quality classification which divides processed and unprocessed material is left as an option to the model user (see Appendix A, Section A.2). Initial production runs used as unprocessed material and sand whose quality was worse than C and any gravel whose quality was worse than D. (New York State Department of Public Works, Division of Construction [1962]).

If the unprocessed sand and gravel operator owns or has access to other potential quarries, it is assumed that he will self-preserve his operation in the event of zoning restrictions or physical depletion. It is further assumed that only as a last alternative will the unprocessed sand and gravel operator switch to a processing type operation in an effort to self-preserve.

In the single quarry operation, the owner of a zoned out or depleted quarry will choose as his new quarry that one which will supply the weighted geometric center of unprocessed sand and gravel at the lowest total cost. In the multi-quarry operation, he will choose as a new quarry that one which will supply the zoned out or depleted quarry at the lowest total cost. The rational behind these decisions is the same as those in the processed sand and gravel operation. Since no processing is involved, the alternative of using an intermediate point is not applicable.

4.48 The Crushed Stone Operation

The alternatives facing the crushed stone operator are the same as those facing the unprocessed sand and gravel operator. The crushed stone operator will seek to self-preserve his operation only if he owns or has access to other potential crushed stone quarries. Since intermediate processing in the crushed stone operation is not employed, the one quarry operator will choose that quarry which will supply the weighted geometric center of crushed stone at the lowest total cost, and the multi-quarry operator will choose the one which supply the zoned out or depleted quarry at the lowest total cost.

It must be noted that the assumption has been made that the crushed stone operator will not investigate, as alternatives, sand and gravel supplies. The detailed flow diagram for the crushed stone self-preservation model is given in Appendix C, page 8.

4.50 Date Processing Section (MINEDP)

Included in the data processing control section are four major functions: 1) The data preparation section which accumulates all output information, determines all costs, and physically prepares and prints these records, 2) The quarry assignment model which assigns quarries to works-in-process, 3) The quarry selection model which establishes new quarries when demand exceeds potential output, and 4) The end of period adjustments which includes the section which reads intermediate data (see Appendix A, Section A.6). These sections are described below.

4.51 The Data Processing Function*

This section converts developments forecasted which are scheduled to begin during the present period to works-in-process and investigates each work-in-process to determine whether a quarry is assigned to it. It then tests whether the assigned quarry can continue to supply the work-in-process. If none are assigned or the assigned quarry can no longer supply the work-in-process,** control is passed to the quarry assignment model (see Subroutine SRFLCQ, Section 4.42). In both of the above cases, a new quarry is assigned to the work-in-process by the model. Also, quarry assignment can be forced yearly at the user's option as explained in Appendix A, Section A.27.

---

*See Flow Chart, Appendix C, pages 9-10; and coding, Appendix D, statements 1510-1842.

**The ability of a quarry to supply a work-in-process is based on whether the assigned quarry has been zoned out or depleted and whether the expected demand from the work-in-process being established exceeds the maximum yearly output of the quarry.

Once it is determined which quarry will supply a certain work-in-process, the data processing function simulates the movement of material from the quarry to the work-in-process by updating the amount of material required at the work-in-process and at the quarry site. All costs incurred are accumulated and all miscellaneous records are kept (see output format, Appendix A, Section A.7). Total costs is determined by

$$TC_{j,t} = A_{j,t} \bullet C_j ,$$

where:

$TC_{j,t}$ = total cost to supply work-in-process j during time period t,

$A_{j,t}$ = tons material required at work-in-process j during time period t, and

C_j = cost per ton (using lowest cost alternative) to supply work-in-process j.

The determination of C is discussed in the following section.

4.52 The Quarry Assignment Model (SRFLCO)*

Although the quarry assignment model (including the new quarry selection model) is written as a subroutine, it is actually an integral portion of the data processing section and therefore, not included in the subroutine control section. This model assigns quarries to works-in-process and establishes new quarries when demand exceeds present output capabilities. Assignment is based on which quarry can supply material of at least the required quality at the lowest cost per ton. All quarries which: 1) have not been zoned out or depleted, 2) produce the required type material (sand and gravel or crushed stone), 3) produce the required quality (or better) material, and 4) do not exceed maximum yearly output as a result of the new assignment will be investigated and the one with the lowest total cost chosen. It must be noted that when the quarry→intermedidate point→work-in-process combination is being investigated, maximum yearly output of the intermediate processing plant is the deciding factor, not output at the quarry supplying the material since yearly output is a function of (mainly) plant capacity.

---

*See Flow Diagram, Appendix C, pages 12-13; and Coding, Appendix D, statements 2508-2809.

Cost directly from quarry to work-in-process is determined by

$$C_{i,j} = c_i + a_i + T_{i,j},$$

where:

$C_{i,j}$ = Total cost/ton for quarry i to supply work-in-process j,

c_i = Cost to mine and process one of ton material at quarry i,

a_i = Amortization cost/ton at quarry i, and

$T_{i,j}$ = Transportation cost/ton from quarry i to work-in-process j.

Cost using the quarry → intermediate point → work-in-process is determined by

$$C_{i,p,j} = c_i + a_p + T_{i,p} + T_{p,j},$$

where:

$C_{i,p,j}$ = Total cost/ton for quarry i to ship to intermediate point p to work-in-process j,

c_i = Cost to mine and process one ton of material at quarry i,

a_p = Amortization cost/ton at intermediate point p,

$T_{i,p}$ = Transportation cost/ton quarry i to intermediate point p, and

$T_{p,j}$ = Transportation cost/ton, intermediate point p to work-in-process j.

Given the above constraints, whichever quarry (or quarry combination) can supply material at the lowest cost/ton will be chosen.

4.53 New Quarry Selection Model - (Flow diagram, p. 13; Coding, Statements 2697-2800)

In spite of the fact that individual operators will, in most cases, perpetuate their own operations, there remains a chance that demand during a given period will not be able to be satisfied by any quarries within or outside the grid system. When this is the case, a new quarry which will supply the given demand at the lowest total cost will be established, and a message stating that demand has dictated the establishment of a new quarry is printed.

For programming ease and model efficiency, it is assumed that if the selected quarry requires processing that a processing plant will be constructed at the site. The possible alternative of using an intermediate processing plant in conjunction with the new quarry site is not considered. In reality, it is very rarely the case that new quarries are opened because existing quarries are incapable of supplying the needed material. In fact, in the experimental runs which are discussed in Chapter VI, the case never arose. Furthermore, when total supply capabilities become so low (or demand becomes so great) that a new quarry is forced to open, it is not unreasonable to assume that the operator will establish a full scale operation which includes the construction of a processing plant at the site.

The cost per ton for a potential quarry to be established and supply a work-in-process is given below.

$$C_{i,j} = \frac{E_i}{L_i} + v_i + t_{i,j},$$

where:

$C_{i,j}$ = Total cost/ton for potential quarry i to supply work-in-process j,

E_i = Establishment cost of potential quarry i,

L_i = Expected life of potential quarry i,

V_i = Cost to mine and process/ton potential quarry i once established, and

$t_{i,j}$ = Cost/ton to transport material from potential quarry i to work-in-process j.

The lowest $C_{i,j}$ is chosen and that potential quarry established as a quarry.

4.54 End of Period Adjustments

At the end of each period, the lives of existing processing plants are updated and new plants purchased when existing plants reach their maximum age. Lives of the new plants are set by the model user (see Appendix A, Section A.2).

As discussed in Appendix A, Section A.6, this section also reads and converts to proper format intermediate data cards at the appropriate years. The flow diagram for the end of period adjustments is given in

Appendix C, page 11, and the coding in Appendix D, statements 2261-2441.

4.60 Subroutines (MINESUBR)

For programming ease, all subroutines (with the exception of SRFLCQ and SRPQCOST) are included within the control section MINESUBR. SRFLCQ has been discussed in Section 4.42 and SRPQCOST is discussed below. Due to the mechanical nature of the other subroutines (from a computer programming standpoint), they are discussed in Appendix B.

4.61 Subroutine Find Lowest Cost Potential Quarry (SRPQCOST)

When a quarry operator is forced to establish a new quarry, he must search all potential quarries owned by him, or to which he has access, and establish that one which will supply a given point (determined by the calling program) at the lowest total cost.

Depending on which alternatives are available to the quarry owner (as determined by the calling program), SRPQCOST will: (1) Search all potential quarries which are capable of supplying processed sand and gravel and chose the lowest cost alternative with and/or without an intermediate processing point, (2) search all potential quarries which will supply unprocessed material and chose whichever can supply material at the lowest cost, or (3) search all crushed stone potential quarries and choose the one which will supply crushed stone at the lowest cost.

The flow diagram for SRPQCOST is pictured in Appendix C, pages 14-15, and the coding in Appendix D, statements 2508-2809.

CHAPTER V

MODEL INPUT

This chapter describes the procedures used in gathering the input data required by MIRSIM. It also describes the problems encountered and suggests how future studies using MIRSIM can be more efficiently conducted.

5.10 Supply Data

Data concerning quarries and potential reserves was originally believed to be readily available and thus provide the fewest data collection problems. As the research progressed, it became apparent that this assumption was fallacious. The data organized by the Bureau of Mines, although very helpful, did not provide the quarry information in as much detail as required by the model. Furthermore, a few large operators and most of the small unprocessed sand and gravel operators do not report their operating figures to the Bureau; hence the data was not complete. We therefore suggest a more efficient procedure for future studies as well as describe the actual procedure followed during the pilot study of the Tri-City area.

Every known quarry supplier within the study area was asked to provide information regarding his quarry site (or sites). The information required from quarry operators includes:

1) Quarry location,
2) Quarry type (sand and gravel or stone),
3) Percentage sand (if sand and gravel),
4) Quality material(s),
5) Quarry life,
6) Yearly output capabilities,
7) Cost breakdown by fixed and variable costs (see Chapter 4, Section 4.42),
8) Life processing plant (if applicable), and
9) Other lands owned.

The details of the exact information required are discussed in Appendix A, Section A.5.

In cases where operators would not reveal the required information, estimates were made based on figures reported by the Bureau of Mines or by geologists familiar with the area.

If a quarry is known to supply material to the study area but is not contained within the boundaries of the grid system, information concerning these "outside quarries" includes:

1) Type quarry,
2) Quality material, and
3) Cost to the grid system.

This information is described in detail in Appendix A, Section A.4.

Although there may be a considerable difference between a quality "a" and "c" sand, we have made no distinction between the two.* Qualities "a", "b", and "c" have been lumped as processed material and below "c" as unprocessed. The same assumptions are held for stone. (Although there is no "unprocessed stone," the qualities "a", "b", and "c", have been lumped as one.) The model is capable, however, of making finer distinctions in the quality than the input indicates. The reason for the broad generalizations is that the data on quality of potential aggregate is impossible to gather unless actual test cores are drilled and analyzed. This was beyond the scope of our project.

There were several assumptions that had to be made with the help of individual operators to complete the input parts of the model. We have assumed a 50:50 ratio of sand and gravel for processed sand and gravel and whereas a 70:30 ratio for unprocessed material. Average F.O.B. prices were established and used as guidelines: $1.75/ton for processed sand and gravel, $1.00/ton for unprocessed, $2.00/ton for crushed stone.

---

*Quality classifications refer to New York State Specifications as outlined in the Public Works Specifications (1962). Classifications are determined primarily by subjecting material on abrasion tests, a magneseum sulfate soundness test, and to a freezing and thawing test. For example see New York State specifications, page 92.

The determination of potential quarry sites was based upon glacial and soil maps. In order to determine the location of economic sand and gravel deposits, a study of glacial and soil maps was undertaken. Glacial maps were available for the study area east of the Hudson River. Albany and Schenectady counties were evaluated by soil maps. Since no soil or glacial maps were available for southern Saratoga county (which constitutes the northern section of the study area), evaluations were made by extending soil patterns from the other three counties included in the study area, Albany, Schenectady, and Rensselaer. The Tri-Cities area was an area of active glaciation; hence only glacial deposits, or glacially associated deposits, were considered as potential sand and gravel sites. The main glacial features which were considered to be potential sand and gravel deposits were kames, kame deltas, kame terraces, eskers, outwash and river channels.

The areas of the three major counties in the study area are Albany, 527 sq. miles; Schenectady, 206 sq. miles; and Rensselaer, 651 sq. miles. The analyses of the maps indicates that about one-third of each of these counties is covered with sand and gravel. In Albany County the deposits are concentrated in the city itself and are therefore unusable under existing conditions. The eastern part of Schenectady County has deposits which lie in a belt extending westward along the Mohawk River. The deposits in Rensselaer, which are by far the best quality, stretch in a north south direction through the western-central part of the county. The wind deposited Colonie "blow sand" covers much of Albany, Schenectady and Saratoga Counties. This sand is very fine and is unacceptable by New York State standards. It may, however, have limited use as fill material.

Of the potential areas of sand and gravel, a conservative estimate of 30% - 40% was considered usuable. In order to simplify calculation, the depth of this material was arbitrarily determined to be 27 feet, a figure considered reasonable by persons having a geologic knowledge of the Tri-City area.

If it is assumed that all the areas were available for sand and gravel operation in the amounts specified, there would be approximately five billion cubic yards available for use. If one assumes an extremely high yearly consumption of five million yards, there would be approximately 1,000 years of reserve.

The potential quarry sites for stone are easier to determine and are even more vast. There are basically three areas from which stone may be produced: the Rensselaer Graywacke which covers about 80 square miles approximately ten miles east of the city of Troy, the Tribes Hill Dolomite which runs along the Mohawk River east almost to Schenectady where it is faulted and lost, and the Helderberg Escarpment limestones which swings an arc from Amsterdam at the west of the study area to Ravena on the south.

As already stated the Rensselaer Graywacke covers about 80 square miles. An overall thickness of 20 yards was used to estimate the volume of stone available. Although the Graywacke is much thicker in places, there are shale beds that make the area unusuable for stone. Using the 20 yards figure as the overall depth compensates for the unusable stone. Even with this estimate there are 48 billion cubic yards or about 100 billion tons of stone available.

Although the Tribes Hill Dolomite extends beyond the western limits of the study region, only that which is directly available to the Tri-City region has been accounted for in the determination of stone reserves. This formation has been considered to be a cliff stretching 10,000 yards, 30 yards in height and 300 yards into the face, representing 90 million cubic yards or about 200 million tons.

The limestone of the Helderberg Escarpment stretch beyond the southern and western limits of the study area; again, only the areas affecting the tri-cities were considered. The escarpment was also treated as a cliff stretching 60,000 yards, with a height of 30 yards and a depth into the face of 300 yards. This produces 540 million cubic yards (1.2 billion tons) of stone.

The estimates of stone reserves are very conservative. For example, no estimate of stone reserves for underground production has been made. Even with this conservatism, the volume of stone should last for thousands of years at extremely high production levels.

In order to better ascertain the exact location of potential supply areas, an aerial survey was conducted by a team of geologists. This survey reaffirmed the authenticity of the previously established potential areas, and revealed a number of heretofor unknown quarry sites. The large majority of these quarries were unprocessed sand and gravel borrow pits; their reserves, and yearly capacity were estimated by the aerial survey team.

The information the model requires about potential quarries includes:

1) Potential quarry location,
2) Type (sand and gravel, or stone),
3) Percentage sand (if sand and gravel),
4) Quality material(s),
5) Life,
6) Yearly output capabilities,

7) Cost breakdown by fixed and variable costs,

8) Estimated establishment cost, and

9) Owner and other lands owned.

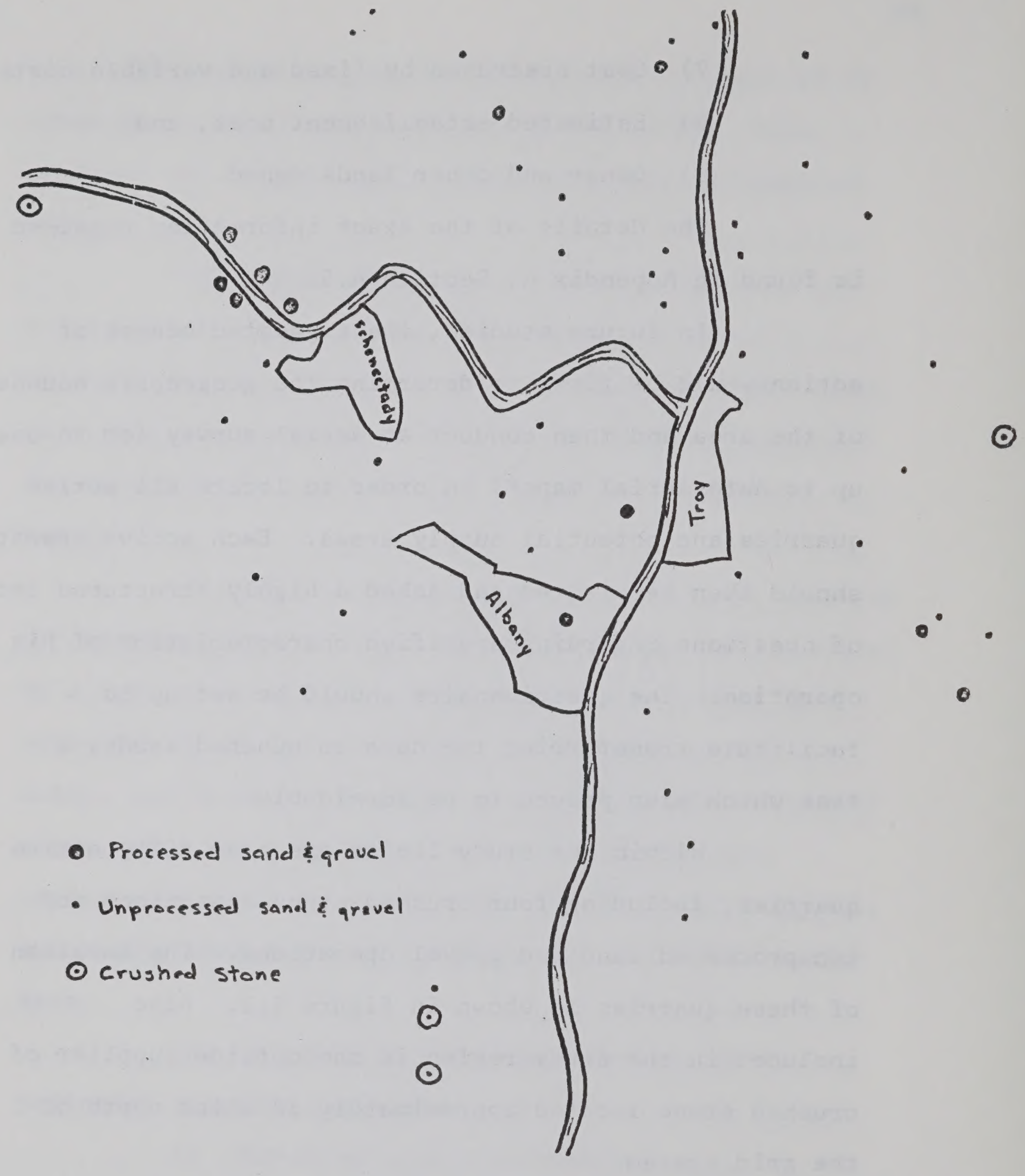
The details of the exact information required is found in Appendix A, Section A.5.

In future studies, the suggested course of action would be first to determine the geographic boundaries of the area and then conduct an aerial survey (or to use up to date aerial maps*) in order to locate all active quarries and potential supply areas. Each active operator should then be visited and asked a highly structured set of questions regarding specified characteristics of his operation. The questionnaire should be set up to facilitate transferring the data to punched cards, a task which also proved to be formidable.

Within the study limits are over fifty active quarries, including four crushed stone operations and ten processed sand and gravel operations. The location of these quarries is shown in Figure 5.1. Also included in the study region is one outside supplier of crushed stone located approximately 10 miles north of the grid system.

---

*Services such as Cornell University's Air Photo Interpretation Center, will photograph and interpret the desired region.



APPROXIMATE LOCATIONS OF QUARRY OPERATIONS IN TRI-CITY AREA

FIGURE 5.1

5.20 Transportation Costs

An average transportation cost which will be used in the model for all material movement must be determined. The transportation cost curve in the Tri-City study region was generally agreed to be \$.25 per ton for the first mile and \$.05 per ton for each additional mile. This cost schedule was decided on by discussions with quarry operators, contractors, and New York State Department of Transportation* personnel. It must be noted that experimental simulation runs (described in Chapter VI) were set up to investigate the effects of changing the transportation cost curve. It may be advisable in other larger urban areas to establish a series of concentric time-distance lines instead of a straight per ton-mile rate. This particular area, however, did not warrant such an elaboration.

5.30 Demand Data

In the model, the demands for mineral resources are created by developments forecasted which are scheduled to begin at a time other than during the first simulated time period, or by projects (works-in-process) which are already in progress at the time of the first simulated period. The data required to identify the characteristics of developments forecasted and works-in-process include:

---

*Formerly New York State Department of Public Works.

1) Demand location (grid row and column),
2) Fill material available from the demand site,
3) Material required (tons),
4) Quality material required,
5) Percentage sand required (if processed sand and gravel),
6) Starting date (if development forecasted),
7) Years it will take to complete project, and
8) Quarry supplier (if it is known which quarry is supplying, or will supply, a project).

The detailed description of the format of the demand data required is presented in Appendix A, Section A.5.

5.40 A Molecular Method for Determining Future Mineral Aggregate Consumption

One of the prime input requirements for MIRSIM is the amount of sand, gravel and crushed stone that will be needed at any given time in an area. The dictates on this information are quite stringent since the requirements for mineral aggregates must be known in terms of a grid coordinate system.

The input to the model must include the governing relationships between sand and gravel consumption and the construction and development plans for the geographic region (in the test case, based on the one mile grids). Therefore, data is required on not only how much land will be devoted to a certain use in any given year (for example, residential use), but also the nature of the construction that will take place, (i.e., one family units or apartments, wood frame or unit construction).

This information can be obtained from hand use projections developed by state or local planning agencies. These projections are usually available in terms of small geographic units, such as one mile square grids, or urban trip-density zones and forecast the amount and location of land devoted to specified uses, such as residential, commercial or industrial. This information must then be translated into the nature of the construction for the projected land use by consulting the sources that govern construction; building codes and zoning laws.

Building codes, for example, may force the design of a building by constraining its size (area covered) and the number of stories. In addition, whether or not the lot lies within the "fire limits" of the city will further dictate the architect's use of steel or concrete frame construction.

In residential construction, zoning laws will usually predetermine whether residences will be one family, two family, or apartment units. A classification by size of unit is sufficient for computing demands on common mineral resources.

Estimates of actual sand and gravel requirements were obtained from the National Portland Cement Association. Based on a nationwide survey, the Association has determined that the average house size is 1200 square feet, and that 65 barrels of cement are needed to complete its construction. There are similar averages for non-residential buildings which give the cement requirements for various types of construction on a per square foot basis.

Since this report deals with the Tri-City area (an area in which soil conditions. climate and many other factors are well established), sand and gravel construction requirements which are more sophisticated than the preliminary data supplied by the Portland Cement Association were made. For example, a much more realistic residential house size based on the size of the lot and where it is located was derived. In addition, a knowledge of soil conditions will be influential in determining fill requirements and the configurations of the housing foundations. As a further refinement, the construction forms in popular use in the Tri-Cities area are known. For example, the houses that are erected usually have a concrete foundation with wood frame. Commercial buildings, on the other hand, are generally of the slab on grade type, with either steel or concrete frame depending on the location of the site. The extent to which precast concrete members are used (these might well be shipped from factories outside the study are) needs further investigation.

Road construction is perhaps the most important factor in the determination of sand and gravel construction. It is fortunate, therefore, that our best estimates and projections for sand and gravel requirements are in the area of road construction. Projections for new roads are made by the state or county far in advance of actual construction. For example, definite commitments have been made by New York State for roads to be built through 1980. In addition, state and county specification predetermine the exact construction of the road, and hence, the amounts of mineral aggregates. The procedure for converting this information to model input is: (1) identify the grids in which projected roads will lie, and (2) estimate aggregate requirements on the basis of the road specifications.

The remaining sections of this chapter describe the data of the mineral aggregate requirement projection procedure.

5.41 Forecasting the Number of Residential Units

The basic equation for determining material requirements created by residential housing is as follows:

(total S&G required)=(no. of housing units)x
(quantity/unit).

It must be noted that in the residential sector the important factor is the housing unit, whereas in the non-residential section, square feet of floor area is the dominant factor. Since the size of housing units and amount of material used does not vary greatly, a house size of 1200 square feet was used for the runs presented in this report. However, should such a sensitivity be necessary for other studies, Table 5.1 correlates lot size with house size and concrete requirements.

LOT SIZE	HOUSE SIZE	CONCRETE
up to 8000 ft.	1000 sq. ft.^{2}	59 cu. yd.
8000 to 12,000 ft.	1200 sq. ft.^{2}	68 cu. yd.
12,000 up	1500 sq. ft.^{2}	80 cu. yd.

CONCRETE REQUIREMENTS VS. LOT AND HOUSE SIZE

TABLE 5.1

In our study area, structures larger than two family types occur infrequently and just in central city areas. This fact is substantiated by the Business Fact Book for the Capital District (New York State Department of Commerce, [1963]) as shown below.

	% HOUSING UNITS IN			
County	1 family	2 family	3-9 family	10+ family
Albany	49.4%	25%	20%	4%
Rensselaer	55	27	14	3
Saratoga	81	11	6	1
Schenectady	60	24	11	5

HOUSING SIZES IN THE STUDY AREA

TABLE 5.2

Discussions with construction firms and planners, also led to the following observations: (1) the current rate of large apartment house construction is small when compared to the overall construction volume,* and (2) over the period of this study large apartment units will play a minute role.**

Table 5.2 shows that a sizeable percentage of housing units are in 3-9 family structures. Zoning indicates that where multi-family dwellings will be erected, they will be in the range of 4-8 family, 2 story units of the "garden apartment" variety. Of the garden apartment currently being built, the majority are wood frame structures in which the concrete per unit is approximately the same as for private (1 and 2 family) dwellings.

---

*The only large apartment house under construction presently is in the city of Cohoes, N.Y. Even a relatively large project, like the Kennedy Tower in Troy, N.Y. (265 units) represents only about 9,000 yds., 6 fine aggregates, and 13,000 yds. of course aggregate.

**In other areas, such as New York City where high-rise apartments are of significant number, the volume of concrete per unit will have to be re-evaluated. Nevertheless, homes in the Metropolitan area are generally of masonry (as opposed to wood) and the quantity of concrete per unit will also be a constant that is independent of the type of unit.

Returning now to the original equation:

(total S&G)=(no. of housing units)x(quantity/unit), it can be seen that the first step is forecasting the number of units. Originally this was done on the basis of zoning (i.e., total land area devoted to residential use/minimum lot size per house = number of dwellings) as follows: zoning maps were obtained from all towns that were zoned and the maps were reproduced to the proper scale and mounted on the base map. The grid overlay then showed the types of zoning that could be associated with each grid. In the case of areas that were not zoned, estimates were made based on field observation, and zoning in adjacent areas. In the case of two or more residential zoning types an estimate was made of the portion of the area that each type represented and an average was determined.

This method worked well in most cases. The few exceptions are in agricultural zones, where an ordinance defines the minimum acreage for farm use, but not the minimum lot for residences, and in residence zones were both single and two or three family dwellings are permitted but on different lot sizes.

For the entire study area during the period 1965-1970, 12,389 residential units were projected for a population increase of 36,470. The per unit population for this period, therefore, is 2.94 persons per unit, a difference of 9% from the 1960 figure of 3.26 person per unit as reported in the Business Fact Book (New York State Department of Commerce, [1963]). For the period 1975-80, the total housing forecast is 3.08 persons per unit, a deviation of 5.6% from the 1960 figure.

For future application of the molecular forecasting method, two methods are open for determination of number of units. Depending upon availability of data, either the zoning method:

(no. units)=(projected residential land)x
(minimum lot size),

or the method of population:

(no. units)=(population)x(pop./unit),

may be used. For initial evaluations the four county average population unit has been used. These figures are, however, available by individual towns and cities, and will be input into the program on the basis of individual zones.

5.42 Concrete Requirements for Residential Construction*

This analysis was performed for three different house-sizes, 1000 square feet, 1200 feet and 1500 square feet. In each case, the house considered had a poured basement with 4" concrete floor, a 10 x 10 ft. patio, 3" thick, wood frame and suitable siding.

A sample calculation for a 30 x 40 ft. house is as follows:

basement floor $1200\ \text{ft}^2 \text{x} 1/3\ \text{ftx}\frac{1\ \text{yd}^3}{27\ \text{ft}^3} = 14.8\ \text{yd.}^3$

foundation wall $1\text{ftx}140\ \text{ftx}10\ \text{ft x } \frac{1\ \text{yd}^3}{27\ \text{ft}^3} = 51.8$

patio (approximately) $\underline{1}$

$68\ \text{yds.}^3$

Similar analysis for 1000 sq. ft. house yielded a total of 59 yards^3; for 1500 ft. house, 80 yards.^3

5.43 Forecasting the Floor Area of Non-Residential Construction

The basic equation for determining floor area of non-residential construction is as follows:

(Total floor area)=(total land)x(maximum coverage of land permitted by local zoning).

---

*See Section 5.41, Calculating Concrete for Non-Residential Construction for a justification of the analytical way in which these concrete estimates are made.

It is felt that using the maximum allowable coverage is realistic since a man who owns land that has a non-residential zoning will try to use as much of it as he can for income producing purposes. If he is not in a position to develop all of his land to allowable capacity, it is assumed that he will sell or lease portions of it for other people to develop. There is no question in our study area of the demand for land and development since the New York State projections are made from a model which takes these factors into account.

Superimposing the grid overlay on the zoning maps, the type of coverage permitted in each grid was determined. When more than one non-residential type appeared the allowable coverage was averaged. Coverage in the study area ranged from as low as 25% of the lot in rural towns to 90% in cities. It must be noted here that no differentiation was made between the various types of non-residential zoning such as light, commercial, industrial, heavy industrial, etc. and that only the allowable coverage was recorded.*

The product of the allowable coverage and the total land is the floor area. The following section describes how the quantities of aggregate are determined.

---

*If sensitivities should indicate a need for further refinement in the future, the varying types of non-residential zoning might be an indication of the type of building that will be erected and hence more than one "typical" structure might be analyzed for concrete usage.

5.44 Concrete Requirements for Non-Residential Construction

Once the floor area of non-residential construction has been forecasted for each grid and time period, the next step in determination of aggregate quantities is the calculation of the cubic yards of concrete that will be required by the construction. A number of approaches were possible. The first, was a survey of local construction firms. The purpose of this survey was to find out the actual quantities of aggregate material that the firms had used on previous jobs.

Presented below is a partial list of the findings:

Job Type	Cubic Yards Concrete / Area of Building
Junior High School	.025
State Police Academy	.063
Boys School	.024
School	.018
Industrial Plant	.028
Warehouse and Office Building	.029
Commercial Building	.0296
Commercial Building	.025
Labor Temple	.010

EXAMPLE CONCRETE REQUIREMENTS ON SELECTED STRUCTURES

TABLE 5.3

The overall average for all jobs surveyed (23) was .04 cu. yds. of concrete per sq. ft. of floor area.

After meetings with the Portland Cement Association personnel, it was decided to estimate the concrete needs on the basis of an analysis of building plans of "typical" structures. A typical building is a one floor structure with a concrete floor and a 3 ft. deep concrete foundation wall. It is assumed that the frame will be steel, with a construction bay size of 25 x 25 ft. There also is a metal or lightweight roof, and a masonry (brick) facade.

The most convenient way of analyzing this structure is on the basis of the construction bay. Each 25 x 25 ft. bay consists of:

625 sq. ft. of 5" concrete floor	13 cu.yd. concrete
one column footing (4 quarter columns at each corner) + cap	1.2cu. yd.
pro-rating of foundation wall and footing to the individual bay	3.1cu.yd.
	17 cu. yd. concrete/bay

Therefore, concrete required for building =

(floor area in (sq. ft.)/(625 sq. ft./bay) x
(17 cu. yds. conc./bay)=17 cu.yd./625 sq. ft. = .027.

Checking this analysis against the findings from actual construction projects it can be noted that our analysis is accurate for most buildings. The few notable exceptions (the ones which drew the average up to .04 yds/sq. ft.) are massive public buildings such as the Police Academy, certain schools, and large, high rise office buildings. These do not represent a large portion of construction volume in the entire study area over the 20 year period.*

Initial structural analysis was made using a 25 ft. square bay, a size that is quite popular today. However, there seems to be a trend for increasingly larger bay sizes; it seems, therefore, that an analysis using 30 ft. bays (20 yds. concrete per bay) may be more suitable for forecasting purposes.

Notably absent from our analysis has been the superstructure of the building. The reason for this is that materials in the superstructure can be identified in a different manner. As previously noted, the superstructure of the building may be steel, in which case it is of no interest to us. If the building is a wall bearing type with masonry (concrete block) units, then these units are identified as a finished product at the manufacturer's plant. In other words, we determine the amount of sand and gravel or lightweight material the manufacturer uses to make his block, (i.e., the block manufacturer is the consumer of the aggregate mineral).

Of increasing popularity in this area will be the tilt-up method of casting a wall on the ground and then "tilting it up" to place. In such a case there is no foundation wall since the tilt up is set right on the foundation piers.

---

*The method presented in this paper can be applied in other areas, although "typical structures" and concrete usages will have to be re-evaluated.

In total, the exceptions to our "typical" structure represent a maximum deviation of approximately 20% in the amount of concrete needed on a per square foot basis. Since these exceptions are not frequent, and since the deviation is only about 20% it was decided to treat all non-residential buildings as "typical".

5.45 Determining the Quantities of Sand and Gravel for Residential and Non-Residential Construction

The final step is to convert concrete quantities to mineral aggregate quantities. For this conversion, it has been decided to use a six bag mix having a water-cement ratio of six to one. This mixture is widely used in severe climates (such as the study area) for most ordinary construction work. For the mixture chosen, each cubic yard of concrete contains 1170 lbs. of fine aggregate, (sand) and 1760 lbs. coarse aggregate (gravel).

5.46 Determination of Aggregate Quantities for Roads

Road construction creates the largest requirements for mineral aggregates in the Tri-Cities area. This statement is readily seen by the fact that a mile of four-lane urban arterial displaces between 75-100,000 tons of aggregates.

Forecasts of road work were obtained from the New York State District I Transportation office.* This office is reponsible for the construction of all roads in the Capital District. The forecasts obtained were not merely projections, but actual plans for highway construction through the year 1979 along with estimated paving costs and projects lengths in miles. The projects were plotted on a transparent overlay of our area map in order to determine the grid(s) associated with each project. By an analysis of a typical cross-section of a road, the tonnage of the various aggregate material was then calculated. The calculations yielded tonnage for: (1) unwashed gravel (fill material), (2) washed gravel (foundation course), (3) stone (used in either the asphaltic or cement concrets), and (4) sand (in the case of concrete cement roads) for each grid during each one of the forecast periods.

---

*New York State "Action Program" for road construction.

CHAPTER VI

RESULTS AND CONCLUSIONS

6.10 Validating Procedures

As previously discussed, an assessment of the validity of a simulation model must be made before its output can be used to aid the decision making process. Validation of MIRSIM has been carried out at three segments of the mineral aggregate study: the validation of the input data, of the model itself, and of the generated output.

6.11 Input Data Validation

Data concerning residential and non-residential construction were obtained from the New York State Capital District Transportation Study in the form of computer generated punched cards. These data, together with road construction forecasts have been discussed with planners, Department of Transportation personnel, and others, and compared with production figures of mineral aggregates in the study area. Because of the confidential nature of individual quarry production figures, the results of the validity tests can only be discussed in broad terms.

Processed sand and gravel requirements through the year 1981 compared very well (on an average yearly basis) with average production figures for the years 1965-1968. U. S. Bureau of Mines figures showed total production in the study region to be approximately 1.1 millions tons in 1965, and 1.2 million tons in both 1966 and 1967. Simulated usage forecasted for the years 1968-1969 averaged 1.25 million tons, with an overall average of 1.3 million tons over the entire 13 year time period.

Historical data on unprocessed production is extremely difficult to obtain. Furthermore, although the total material requirements may very well be accurate, the actual amount that must come from quarries (as opposed to that fill material which is obtained from the construction site itself) must also be estimated. Average yearly production predicted by the model was 600,000 tons. Of this, the model allocated 200,000 tons to the very large suppliers, and the remaining 400,000 tons to the many small producers scattered throughout the study area. This small producer average of approximately 11,000 tons per year compares very well with an estimate of between 5,000 tons and 50,000 tons produced by the unprocessed supplier, the estimated modal value being between 10,000 and 15,000 tons.*

---

*Personal correspondence with Mr. William Cutcliffe, J. R. Dunn and Associates, Averill Park, New York.

The first four years of the simulated time period resulted in an average yearly production of 1.2 million tons of crushed stone. Actual production figures showed that approximately 1.4 million tons were produced in 1967. The 200,000 ton discrepancy is accounted for in that not all stone produced was shipped into the study region, and miscellaneous small road projects have not been considered.

It must be noted that actual total production in the Tri-City area in 1967 was approximately 1.6 million tons. This added 200,000 tons, which is used for residential and non-residential structures, for sewers, and for canal and railroad bed maintenance has not been considered in the experimental runs which follow. Discussions with the president of a major producer of crushed stone in the study area reinforced the original belief that sone produced for these uses amounts to an insignificant percentage (less than 5%) of total production. Hence, it has been decided that the cost of forecasting these demands does not justify the marginal added realism gained by their inclusion.

Production figures over the entire simulated period average only 600,000 tons per year. The decrease after the first four years can be accounted for by the fact that many of the large New York State road construction projects presently underway are scheduled for completion within these years and no new major jobs are forecasted.

Data describing the characteristics of the individual quarry operations were obtained from the operators themselves and by estimating procedures determined by the geologists involved with this research. Follow-up discussions with a number of major operators, with the Executive Secretary of the Empire State Sand, Gravel and Ready Mix Association, and with U. S. Bureau of Mines personnel resulted in the opinion that the projections made by the model were "not at all unexpected".

It was assumed that the cost of processed sand and gravel at the quarry site varied between $1.70 and $1.90 per ton. It must be noted that in actuality, this cost has risen to slightly more than $2.00 per ton. Therefore, the simulated dollars spent for processed material is slightly less than can be expected under the updated cost structure.

Because of the large number of small unprocessed sand and gravel producers, it was decided that it was not economically justified to visit with them. The estimation of the type, quality, and quantity of material they produce has been further complicated by the fact that most of them do not report their figures to the Bureau of Mines or to the Sand and Gravel Association. In order to describe their operations to the model, the size of the operations (with respect to output capabilities as well as reserves) was estimated from the previously discussed aerial survey. For simplification purposes, it has been assumed that each operator produces a run of bank material at $1.00 per ton at the quarry site.

6.12 Model Validation

The decision processes included within the model itself were developed from the results of discussions with U. S. Bureau of Mines personnel, geologists familiar with mineral aggregate production in the Tri-City area, and by the producers themselves. These discussions continued throughout the entire modeling procedure for the purpose of analyzing in detail the many facets of the model itself.

Debugging of the actual computer program (to insure that it was functioning correctly from a programming viewpoint) also continued throughout the entire programming stage. Numerous sets of test data (which could be hand checked by desk calculator) were conducted on individual sections of the model. When these individual sections were functioning properly (within the limits of the test data), the model was run with actual data. The first set of runs using actual data was used strictly for final programming checks. Only after the final set of debugging runs (at which point it was felt that the model was behaving properly) were the actual runs started. The results of these runs are discussed in Section 6.20. Two major assumptions were made during the development of the model: those involving the determination of a weighed geometric center of demand as a focal point for new quarry establishment, and the assumption that quarries would be assigned to works-in-process on a low cost basis.

During the initial interviewing process, quarry operators were asked where they would open new sites if their present ones were zoned out. The consensus was that each operator would make a judgment (based on previous knowledge, announcements of future developments, etc.) on the location of the center of the demand pattern and try to locate his new quarry in as competitive a position to that location as possible. Through the use of a weighted geometric center (as described in Chapter IV, Section 4.45), the model has quantified the estimating procedure described by the operators. The weighted geometric centers, as determined by the simulation runs, are located approximately one mile due north of the City of Albany. This center is well within the centers estimated by the quarry operators.

The assumption of assigning whichever quarry could supply material at the lowest total (delivered) cost also proved to be very reasonable. As previously discussed, for large construction projects, jobs are bid upon and the low cost bid accepted. In smaller jobs, other factors such as family ties and so forth may tend to distort the assumption of low cost. These amount to such a small portion of the total usage that it is felt that, in general, the low cost assumption is, in fact, valid.

6.13 Output Validation

The first attempts to validate model output were accomplished by running the model with test data specifically designed to cause certain reactions by the model. Using very simple cases, the results of simulation runs were checked by hand. Only after all test cases were running satisfactorily was the model run with the actual Tri-City data.

If it is assumed that the input data (both supply and demand) is reasonable, the generated output can be validated as a function of that input data. Balderston and Hoggart (Amstutz [1967], p. 380) suggest that "...our first concern is scheduling runs of the model was to establish its viability: that is, its ability, under plausible initial conditions and parameter settings, to generate behavior over time...".

Cost at quarries are approximately $1.00 per ton for unprocessed sand and gravel, $1.70 for processed sand and gravel, and $2.00 per ton for crushed stone. With a transportation cost of $.25 per ton for the first mile and $.05 per ton for each additional mile, average simulated costs of delivered aggregates are $1.85 per ton for unprocessed sand and gravel, $2.60 per ton for processed sand and gravel, and $3.00 per ton for crushed stone. These figures compare well with real world costs. Of the $84,900,000 spent for mineral aggregates, the model projects that $29,500,000 (34.8%) will be spent for transporting material from quarries to demand points, a figure which is very accurate for the Tri-City area, the rule of thumb in the study region being 1/3. Average hauling distances also proved to be very reasonable from both the geometry of the study region as well as from actual transportation distance figures. One major crushed stone producer (for example) estimated an average hauling distance of 14 miles which compares very favorably with the simulated average of 14.6 miles.

In order to assist in the validating process, the model provides the ability to investigate the simulated production figures for each quarry on a yearly basis. Attempts to compare quarry production with simulated production have been greatly hampered by the fact that the latest production figures are through 1967 and the simulation data is such that the first simulated time period is 1968. Since available production figures for 1965, 1966, and 1967 showed no noticable trends, it was decided that any comparison between the historical and the simulated data would add little toward validation.

On a quarry by quarry basis, the model is a poor predictor in areas where quarries tend to be grouped. If all quarries in the group are selling material at the same price at the quarry site, the quarry closest to the center of activity supplies the largest amount (in some cases all) of the required material. This choice in the model is expected because of the non-competitive nature of the allocation process. In actuality, quarry costs are flexible enough to allow operators to adjust their prices and thus prevent one quarry from being the dominant supplier within the group.

In those areas where quarries are grouped, however, the total actual production from the group can be compared with the average simulated production from that same group. The average percentage of total production at the two major processed sand and gravel quarry groups generated by the model was within 2% of the actual average percentages for 1965, 1966, and 1967.

The question, "Is this a reasonable answer?" is asked whenever output is analyzed. Hence, validation of output is a continuing process and is (implicitly) described throughout the remainder of this chapter.

6.20 Analysis of Generated Output

The initial runs were set up to investigate basic aspects of the model and to provide an overall indication of the magnitude (in terms of tons and dollars) of the mineral aggregate producer-consumer system in the Tri-City area. They represent the system as it actually is at the present time. Unless otherwise stated, all runs have been conducted for a 13 year period* with a transportation cost of $.25 per ton for the first mile and $.05 per ton for each additional mile. Tons of material required are 17.8 million for processed sand and gravel, 7.8 million for unprocessed sand and gravel, and 8.1 million for crushed stone.

The first three runs were set up for determining average execution time and the effect of either: assigning quarries to works-in-process each year, assigning quarries to works-in-process whenever new quarries are added to the system, or assigning quarries only when the previously assigned quarry can no longer supply the needed material* (The three assignment options are discussed in Appendix A, A.2.).

---

*The data generated by New York State commences in 1968. Road construction forecasts are given through the year 1980, and all other construction through 1985. Hence, a 13 year simulation run (through 1981) is used throughout the study.

It is most realistic to assign quarries (based on a lowest cost) to works-in-process each year since contracts between producers and consumers are usually drawn up on a seasonal basis. However, since initial assignment is determined on a low cost basis, it is reasonable to assume, that if no new quarries are added to the system, that assignments will remain virtually the same as if assignment had taken place each year. Since the assignment procedure is the most time consuming aspect of the program operation, it was thought that re-assigning only whenever at least one new quarry was added to the system would not greatly affect the cost and would significantly reduce execution time. Assigning each year resulted in a total cost of $83,100,000 with an execution time of 200 seconds. Assigning whenever a new quarry is added resulted in a total cost of $84,900,000 with an execution time of 120 seconds. The increased cost of only 2.2% was accompanied by a significant 39.4% saving in time.

---

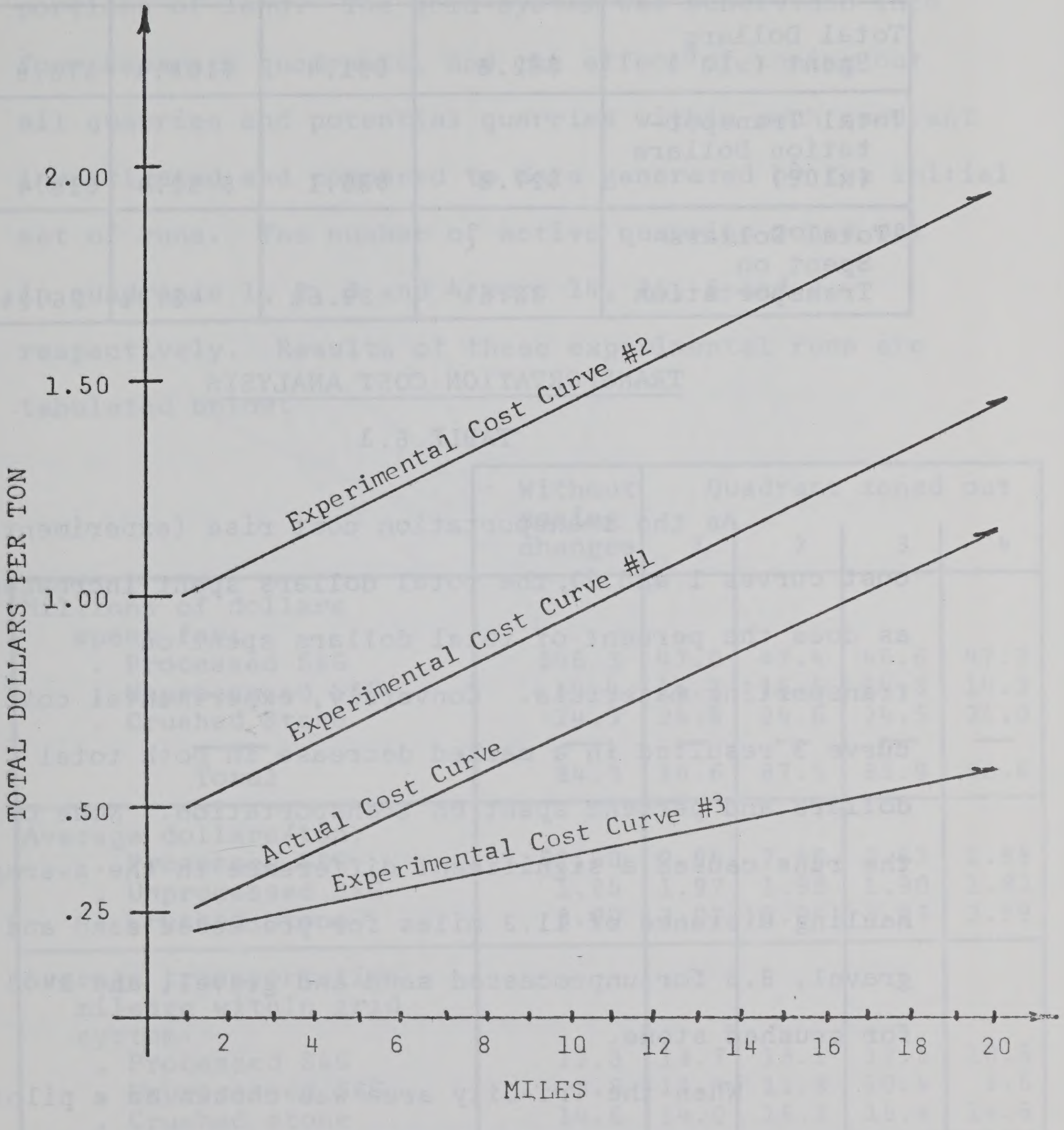
*It must be noted that even when a new quarry is not assigned, the previously assigned one is checked to see if it can still supply the required material. If not, a new assignment is made.

The third alternative, to reassign only when the assigned quarry can no longer supply a work-in-process, resulted in a total cost of $84,600,000 with a run time of 110 seconds. This alternative is, however, much less realistic than either of the above and is therefore not used in further runs.

Since it is not unreasonable to assume that contractors will continue to buy material from the same operator for the same job, and because it was felt that the marginal benefits gained in realism were worth the added computational time, the "assign whenever a new quarry is added" option has been used in the remaining runs.

In order to test the model's sensitivity to changes in transportation costs, runs with three hypothetical cost curves were compared with the actual cost curve used throughout this study (See Figure 6.1). The actual cost curve and experimental curves 1 and 2 have a slope of $.05 per ton-mile. Experimental curve 3 could be the result of an innovation in transportation technology which would result in the lower cost of $.20 for the first ton-mile and $.03 for each additional mile.

The simulated results of these runs are given in Table 6.3.



EXPERIMENTAL TRANSPORTATION COST CURVES

FIGURE 6.1

	Transportation Cost Curves (See Figure 6.1)			
	Actual	1	2	3
Total Dollars Spent ($x10^6$)	\$82.8	\$91.4	\$108.4	\$73.8
Total Transportation Dollars ($x10^6$)	\$27.8	\$36.1	\$ 52.4	\$19.4
%Total Dollars Spent on Transportation	33.6%	39.5%	48.3%	26.2%

TRANSPORTATION COST ANALYSIS

TABLE 6.1

As the transportation cost rise (experimental cost curves 1 and 2), the total dollars spent increases as does the percent of total dollars spent on transporting materials. Conversly, experimental cost curve 3 resulted in a marked decrease in both total dollars and percent spent on transportation. None of the runs caused a significant difference in the average hauling distance of 11.3 miles for processed sand and gravel, 8.5 for unprocessed sand and gravel, and 14.3 for crushed stone.

When the Tri-City area was chosen as a pilot region, it was the consensus that aggregate supplies were abundant within the study region. This preconceived opinion was strongly supported by the initial runs, as no major changes in the quarry configuration were made over the simulated time period.

The next four runs were set up to determine the effects of radical zoning changes affecting large portions of land. The grid system was subdivided into four separate quadrants, and the effect of zoning out all quarries and potential quarries within each quadrant investigated and compared to data generated by the initial set of runs. The number of active quarries zoned out in quadrants 1, 2, 3 and 4 were 14, 25, 6 and 9 respectively. Results of these experimental runs are tabulated below:

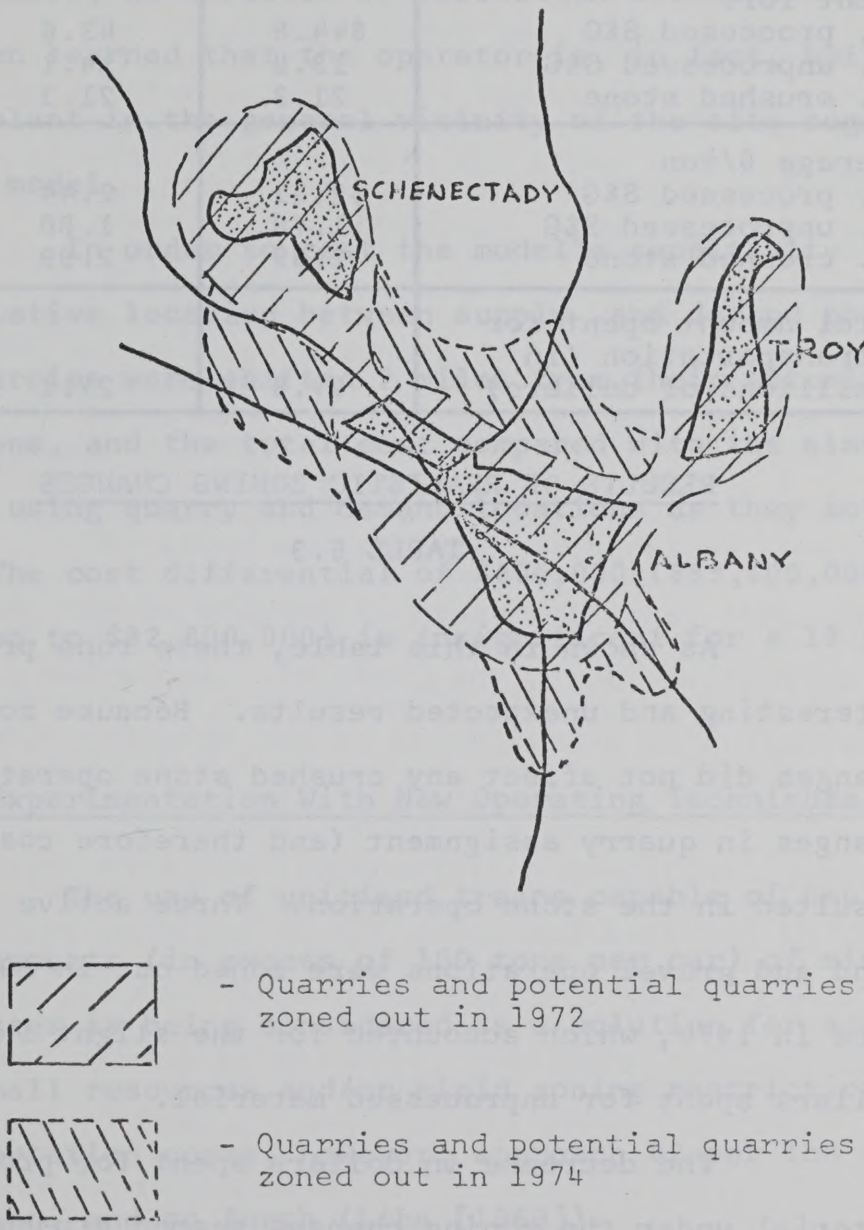
	Without zoning changes	Quadrant zoned out			
		1	2	3	4
Millions of dollars spent for:					
. Processed S&G	$46.3	47.0	47.4	46.6	47.3
. Unprocessed S&G	14.4	15.3	15.5	14.8	14.3
. Crushed Stone	24.3	24.4	24.6	24.5	25.0
Total	84.9	86.6	87.5	85.9	86.6
Average dollars/ton:					
. Processed S&G	$2.60	2.64	2.66	2.62	2.65
. Unprocessed S&G	1.85	1.97	1.98	1.90	1.83
. Crushed stone	3.00	3.02	3.04	3.03	3.09
Average transportation mileage within grid system:					
. Processed S&G	12.3	13.7	13.1	12.5	13.5
. Unprocessed S&G	9.8	11.4	11.3	10.4	9.5
. Crushed stone	14.6	14.0	15.1	15.4	14.6

RESULTS OF MASSIVE ZONING CHANGES

TABLE 6.2

The Tri-City area has an abundance of strategically situated quarries and potential supply areas (see Figure 6.1). From the experimental runs tabulated above, it is very obvious that zoning out large sections increase, but only slightly, the cost of delivered aggregates. The total increased cost is only 3.1% in spite of the fact that one fourth of the total supplies are zoned out. As a result of the relocation of quarries and the reassignment of suppliers to works-in-process, average hauling distance also increased, but again, very slightly. It must be noted that when quadrant 1 was zoned out, the average hauling distance for crushed stone decreased. This is because the outside crushed stone supplier, which is near the demand points in the first quadrant, became a major supplier to the area, thus decreasing the total ton-miles within the grid system.

The next two runs were set up to show what would happen under, what might be considered realistic zoning changes. Figure 6.2 graphically portrays the experimental zoning changes that have been made. One run was made zoning out all quarries and potential within the shaded area in 1974 (year 4 of the simulation). A second run was made zoning out the 1972 area in year 4 and then zoning out an additional area in 1974 (Year 6). The results of these two runs (as well as a base run with no zoning changes) are tabulated below.


SCHENECTADY
TROY
ALBANY
▨ - Quarries and potential quarries zoned out in 1972
▨ - Quarries and potential quarries zoned out in 1974

EXPERIMENTAL REALISTIC ZONING CHANGES

FIGURE 6.2

	Without Zoning Changes	Zoning out only in 1972	Zoning out in 1972 & 1974
Total $ spent for all materials (in millions)	82.8	81.9	82.1
Millions of dollars spent for:			
. processed S&G	$44.8	43.6	43.6
. unprocessed S&G	13.9	14.1	14.3
. crushed stone	21.3	21.3	21.3
Average $/ton			
. processed S&G	$2.51	2.44	2.44
. unprocessed S&G	1.78	1.80	1.83
. crushed stone	2.99	2.99	2.99
Total amount spent for transportation (in millions of dollars)	27.8	27.1	27.2

RESULTS OF REALISTIC ZONING CHANGES

TABLE 6.3

As shown in this table, these runs provided interesting and unexpected results. Because zoning changes did not affect any crushed stone operations, no changes in quarry assignment (and therefore cost) resulted in the stone operation. Three active unprocessed sand and gravel operations were zoned out in 1972 and two more in 1974, which accounted for the slight increase in dollars spent for unprocessed material.

The decrease in dollars spent for processed material under the zoning changes seemed strange until a careful investigation of changes in the grid system was made. The 1972 zoning changes required a presently active operator to re-establish his operation in a location which turned out to be more strategic than his present location. The confidential nature of this relocation prevents discussion in further detail, but other test runs have validated the desirability of the new location. Furthermore, as a result of validation discussions, it has been learned that the operator is, in fact, building a new plant in the general vicinity of the site suggested by the model.

In order to test the model's sensitivity to the relative location between supply and demand points, all quarries were shifted 2 miles from their actual locations, and the total cost compared with the simulated output using quarry and demand locations as they actually are. The cost differential of $800,000 ($83,600,000 compared to $82,800,000) is insignificant for a 13 year period.

6.30 Experimentation With New Operating Techniques

The use of unitized trains capable of hauling large amounts (in excess of 100 tons per car) of mineral aggregates is being considered as a solution for areas with small resources and/or rigid zoning restrictions. Transportation costs, however, approach $2 per ton at 200 miles, and so forth (Liba [1969]).

To test the impact of using unit train in the Tri-City area, a quarry capable of supplying "A" quality crushed stone to the center of demand activity (1 mile north of Albany) at a total cost of $3.00 per ton was (hypothetically) established. As expected, the results of this run showed that this method of distributing stone was not competitive in the Tri-City area under existing conditions. Using the low cost assignment procedure, no material was sold by the unit train supplier.

Underground mining of stone has also been suggested in critical areas (Dunn, Wallace, and Baisuck [1967]). This method of aggregate extraction at least doubles the cost of material, F.O.B. the quarry site. Since this method of production is more expensive than the experimental run using unit train, it too would not be competitive within the Tri-City area.

CHAPTER VII

SUMMARY AND SUGGESTIONS FOR FUTURE RESEARCH

7.10 Summary

The simulation model developed in this research has been written specifically for investigating the common mineral system within our urban environment. The ideas, concepts, and methodology, however, have far greater implications. The model can be immediately extended to include consideration of the use to which the land will be placed upon quarry termination; and it can become part of a more general land use model.

The ideas and computer methodology specifically employed can be adapted to resources other than sand, gravel, and stone. In fact, any fixed position, non-renewable resource can be investigated in a similar manner. The low intrinsic value and high bulk of the mineral aggregates make the transportation sensitive property (hence the location of the deposits) critical in the planning process. High value products do not usually have this characteristic and will, therefore, usually be investigated from a viewpoint different than that described in this research. It must be noted, however, that the relationship between the value of the product at the quarry site and the value added by transportation is a crucial one; one example of a mineral being considered as appropriate for analysis by MIRSIM is potash on a national basis.

The vast majority of simulation models which are currently operative have been written in high level languages such as FORTRAN, GPSS, SIMSCRIPT, and so forth. These languages have facilitated the programming phase of model development from both ease of programming as well as the amount of time spent in the debugging stage. There is no doubt that most of the newer, higher level FORTRAN compilers produce a more efficient object code than their predecessors, but their efficiency is, nevertheless, constrained by the requirements of the language itself.

The model described in this research is programmed in Assembly Language to insure an efficiency of execution which is unattainable by the higher level languages. Furthermore, the use of chaining techniques have greatly increased the efficiency of the search procedures. The trade-off between programming ease and model efficiency has been made in a direction opposite to that which is commonly followed; the expected longer programming period has resulted in a model which can efficiently simulate the minearal aggregate system in large geographic areas over extended simulated time periods.

Based on the results of the experimental runs which have been made, it is felt that the added programming time has been well justified. Since MIRSIM is one of the few models which has been designed to simulate real world phenomena and which has been written in an Assembly Language, it is believed that this research has displayed that assembly type languages can be effectively employed in simulation modeling.

MIRSIM has been well received by those who will use it as an aid for real world planning decisions. It has displayed that it can be economically used (from a computational viewpoint) and that the generated output is both realistic and informative. Since it is the only known model which deals strictly with mineral resource planning, both the developmental stage as well as the results of the experimental runs have provided a number of valuable insights toward applying it to other areas whose problems are more serious than those in the Tri-City area. These results are discussed in the following paragraphs.

Although the study area itself proved to be insensitive to zoning changes, the model itself is not. Under test conditions with few quarries and/or potential reserves, zoning changes greatly affected the cost of delivered aggregates. Since it is through zoning that quarries are legally controlled, up to date and accurate zoning data should be collected for the entire study area, and a careful assessment of future zoning changes should be made.

The determination of reserves at quarries and potential quarries can be both difficult and costly. Fortunately, the system has displayed that changes in estimated reserves have little effect on the cost of aggregates. Therefore, estimating procedures such as those discussed in Chapter V should prove sufficient in future studies. The use of statistical descriptions of reserves is discussed in Section 7.20.

Transportation cost is, and will continue to be, a considerable portion of the cost of delivered aggregates. The Tri-City area as well as the model reflects that it is very sensitive to changes in transportation costs. In areas with few suppliers, the determination of the exact locations of quarries and demand points are more important than in locations such as the study area where the many suppliers are uniformly situated throughout the study region. Although shifting the relative location between supply and demand did not significantly affect the cost of delivered aggregates in the study area, in locations with fewer supply points changes in demand locations can be more critical.

In a discussion about the Penn-Jersey, Pittsburgh, and San Francisco models, Wolfe and Ernst ([1967], p. 51) state:

> 1. Each has cost far more to produce than was originally planned!
> 2. Each badly overran the originally planned completion date!
> 3. Not one has yet received effective use for the purpose which inspired their original design!

The development of MIRSIM in its initial form managed to stay within budgetary constraints; actual programming of the model, however, exceeded the originally estimated time by close to one year. It is strongly hoped that the model will, in the future, be applied to the planning which affects the mineral aggregate reserves of our cities.

All of those associated with the development and evaluation of MIRSIM realize its weaknesses as well as its strong points. We strongly feel that simulation models of this type have great potential in the public sector; we feel that ours is a starting point for the evaluation of a problem which has been given little or no consideration in the past. Although the model is as complete as can be expected in an "initial" model, it does not attempt to answer or evaluate all problems relating to common mineral resource allocation. Land values are not considered, nor are land uses after quarry termination. Transportation costs are strictly a function of distance, whereas in the real world transportation time is becoming increasingly important.

It is the desire of all those associated with this research that MIRSIM will be used for more than academic purposes. We welcome and solicit changes, additions, and suggestions that its users may have. We therefore outline in the next section, our suggestions for future research in problems relating to mineral resource planning.

MIRSIM is only a small portion of the "total" model for which we strive. It is, nevertheless a tangible part. Whether a "total" or more complete model contains MIRSIM or only the ideas contained within it, we feel that it has and will be an aid for logical and rational decision making within the structure of our growing urban complexes.

7.20 Suggestions for Future Research

In its present form, MIRSIM is a strictly deterministic model. It is believed that the addition of probabilistic elements to the model would increase its usefulness as a simulation model. For example, the lives of quarries and potential quarries could be described by probability distributions, rather than using mean values as has been done in this research. Locations, starting times, and material requirements for forecasted developments could be described in probabilistic terms, and some of the decision processes included within the model itself could be made non-deterministic.

The change from a deterministic to stochastic model utilizing Monte Carlo techniques would make possible a statistical analysis of the generated output, rather than the descriptive discussion as has been done in this research. For example, the mean costs generated by different strategies could be compared statistically, and the significance of the different results evaluated.

The model does not consider the time value of money; monies in the future have the same present value of those spent today. This modification should be considered in future changes or additions to the model.

Finally, MIRSIM has been written in Assembly Language. Although this choice of language has provided a very efficient program from an operational standpoint, it has limited its running capabilities to an IBM/360 computer. Debugging and programming was very difficult, and future changes will be even more so. PL/1 was not implemented at the time this research began; it provides many advantages not offered by such languages as FORTRAN (such as the manipulation of bits of information) and should, therefore, be considered if an appreciable amount of programming changes are to be made. Since it is more readily readable than Assembly Language, the debugging procedure would be greatly facilitated.

MIRSIM has been written for batch mode operation. Its usefulness as a planning tool, therefore, is limited in that (very often) many cards must be punched to try suggested planning strategies. From the user's point of view, a terminal conversational program which could be time shared would be very desirable. Of all the possible changes made to MIRSIM, it is felt that this one should be given a top priority.

The objective of this research project was to develop a computer simulation model that will provide information on common mineral resources to planners in any region. This project started with a small hypothetical city (based on Binghamton, New York); continued with a medium-size metropolitan area as described in this report, and the next phase is, logically, a large urban-suburban region. In the development process, the model was designed in as broad a sense as possible, thus making it readily adaptable to any region. Nevertheless, there will be problems associated with a large metropolitan area that can only be resolved by its application to one. The New York City region would be an excellent test area for this evaluation.

Finally, as has been previously stressed, MIRSIM does not provide normative information. Mathematical programming does optimize, and as described by Little ([1967]), p. 199):

> ....is concerned with the maximization (or minimization) of a function of many variables, particularly in the case where the value of the variables are restricted in some way. Thus, given a numerically measurable objective and given mathematical relations that specify how various available actions relate to each other and to the objective, we seek to

> determine 'how much of what to do when' in order to achieve the largest value of the stated objective.

In this description of the applicability of mathematical programming, two basic factors are implied: (1) there is a desire to optimize, and (2) a measurable objective and a set of given mathematical relationships exists.

Little continues with:

> Strictly speaking, mathematical programming as a field starts after a program has been formulated in mathematical terms. One might conjecture, therefore, that practical problem-solving could be done in two stages: (1) model formulation and (2) model solution.

The system which was studied - the mineral aggregate industry and its relationship with the economy - is highly complex. Initially, little was known about the variables involved; almost nothing about the existing mathematical relationships. This research chose, therefore, to formulate the system as a simulation model and to use the model to study its properties. Enough has been learned about the system to begin the investigation of optimizing techniques as described above. Research at Rensselaer is presently conducted in an effort to apply mixed integer programming techniques to identify these "optimal" strategies.

The final, and most important, suggestion is to use the methodology developed in this report as a basis for investigating the problem of multiple land use.

Forces competing for the use of our fixed position, non-replenishable, resources must be evaluated in similar terms and in concert; it is our hope that this research project represents a beginning.

7.30 An Addendum: An Investigation of the Mineral Resources in the Syracuse, New York Metropolitan Area

The purpose of this addendum is to: (1) report on a study presently being conducted by the New York State (N.Y.S.) Geological Survey under the direction of Dr. James Davis, State Geologist, and (2) describe the appropriateness of the methodology discussed herein in meeting the objectives of this study.

This study was conducted for the regional planning group whose responsibilities include Onondaga, Cayuga, Oswego, Madison and Cortland Counties, New York. An intensive field study was made of all of the surface mineral extraction sites in the area. Observations were made concerning the following:

1). market areas in which production from each site is consumed;

2). quality and uses of material produced;

3). estimate of remaining reserves; and

4). historical records of past production at the sites.

Using this information, the production sites were categorized into consumption areas. The amount of reserves held by current operators which can ultimately be used in each of these consumption areas was then estimated. The historical information from mineral production of each commodity extracted at the surface was prepared and this data used as one means of forecasting the rate of future production. A correlation analysis was made between construction activity and the production history of mineral aggregates for each county in the region between 1948 and 1967. A forecast of the extent of construction activity to 1990 was made from the industry from 1948 to 1967.

Current efforts include making a comparison between the existing reserve in each market area and the anticipated consumption of these reserves are evaluated by forecasting from historical information. This permits the regional planners to be aware of the areas in which shortages of mineral material will develop and the approximate dates the material held by existing producers will be depleted.

To utilize the computer simulation approach, the information on supplies, both "reserves" - those currently held by producers, and "resources" - those potential sites, must be coded and put into machine readable form. This would involve approximately 1 man-month of effort, requiring virtually no field work. Application of the molecular approach toward development the demand on common mineral resources in that four county region (as opposed to the forecasting methodology employed by the Survey) requires a set of land use projections. These projections are available from the N. Y. S. Department of Transportation and will require approximately 2 man-months of effort for necessary reprogramming and conversion to the format required by the model.

Efforts are continuing to perform this evaluation by comparing the output of the N. Y. S. Geological Survey study with the results of the computer simulation runs. It is hoped that this analysis will permit a cost/benefit determination of the computer simulation approach.

BIBLIOGRAPHY

Ahearn, Vincent P., Jr. Land Use Planning and the Sand and Gravel Producer. Silver Springs, Maryland: The National Sand and Gravel Association, 1964.

Ahearn, Vincent P., Jr. "Urbanization, Land Use Controls and the Mineral Aggregate Industry." Presented at the annual meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers, Chicago, Illinois, February 17, 1965,

Ammann, O. H. "Design Concepts and Construction Procedure." Civil Engineering, Vol. 34, No. 12, December 1964, pp. 39-42.

Amstutz, Arnold E. Computer Simulation of Competitive Market Response. Cambridge, Massachusetts: The M.I.T. Press, 1967.

ASPO Planning Advisory Service. "Land Use Controls in the Surface Extraction of Minerals, Part I." Information Report No. 153, American Society of Planning Officials, Chicago, Illinois, December 1961.

Awerbuch, Shimon A. "The Molecular Method for Forecasting Needs for Common Mineral Resources." Unpublished paper, Urban and Environmental Studies, Rensselaer Polytechnic Institute, Troy, New York, 1969.

Baisuck, A., Bhatia, N., Gonen, S., and Lieberman, J. Validation of Computer Simulations." Unpublished Paper, School of Management, Rensselaer Polytechnic Institute, Troy, New York, April 1967.

Bauer, Anthony M. Simultaneous Excavation and Rehabilitation of Sand and Gravel Sites. National Sand and Gravel Association, Silver Springs, Maryland, 1965.

Bell, Joseph N. "Where Do the Rock Industries Fit in Urban Planning?" Rock Products, November 1962, pp. 51-53.

Bishko, Donald. "Planning For Common Mineral Resources in The Urban - Suburban Environment: A Computer Simulation Approach." Unpublished Doctoral Thesis, Rensselaer Polytechnic Institute, Interdisciplinary Committee on Computer Science, August 1969.

Bottge, Robert G. "The Mineral Aggregate Industry in Pennsylvania." Unpublished Master's Thesis, The Pennsylvania State University, Department of Mineral Economics, December 1964.

Clawson, Marion, Held, R. Burnell, and Stoddard, Charles H. *Land for the Future.* Baltimore, Maryland: The Johns Hopkins Press, 1960.

Connors, Michael M., and Teichroew, Daniel. *Optimal Control of Dynamic Operations Research Models.* Scranton, Pennsylvania: International Textbook Company, 1967.

Duke, Richard De La Barre. "Gaming Simulation in Urban Land Use Allocation." Unpublished Ph.D. Thesis, University of Michigan, 1964.

Dunn, James R., and Broughton, John G. "A Mineral Conservation for New York State." *State Government*, Vol. XXXVIII, No. 3, 1965, pp. 191-199.

Dunn, James R., Wallace, William A., and Baisuck, Allen. "Underground Stone Production: The Answer to Many Problems?" *Pit and Quarry*, Vol. 59, No. 10, April 1967, pp. 183-186, 202.

Flawn, Peter T. "Geology and Urban Development." Text of an address made to a *Symposium on Geoscience and Urban Development*, Baylor University, Waco, Texas, February 13, 1964.

Goldman, Harold B. "Urbanization - Impetus and Deterent to Mining Industry." *Mining Engineering*, July 1961, pp. 717-718.

Goldman, Harold B. *Urbanization and the Mineral Industry.* Mineral Information Service, State of California, Division of Mines, Vol. 12, No. 12, December 1959.

Griffiths, J. C., and Drew, L. J. "Simulation of Exploration Programs for Natural Resources by Models." *Quarterly of the Colorado School of Mines, Part A*, Vol. 59, No. 4, October 1964, pp. 187-206.

Haar, Charles M. *Land Use Planning - A Casebook on the Use, Misuse, and Re-use of Urban Land.* Boston, Massachusetts: Little, Brown, and Company, 1959.

Hufschmidt, Maynard M., and Fiering, M. B. *Simulation Techniques in Design of Water Resource Systems.* Cambridge, Massachusetts: Harvard University Press, 1966.

Jensen, David R. *Selecting Land Use for Sand and Gravel Sites*. National Sand and Gravel Association, Silver Springs, Maryland, 1967.

Johnson, Craig. *Practical Operating Procedures for Progressive Rehabilitation of Sand and Gravel Sites*. National Sand and Gravel Association, Silver Springs, Maryland, 1966.

Jordan, Mark H. "Cash Flow Forecasting by Highway Contractors: An Investigation of Current Practice and Future Potential." Unpublished Ph.D. Thesis, Rensselaer Polytechnic Institute, Troy, New York, July 1967.

Just, Leo H., Gray, Homer, et. al. "Tower Foundations and Ancorages." *Civil Engineering*, Vol. 34, No. 12, December 1964, pp. 42-45.

Kilbridge, Maurice D., O'Block, Robert P., and Teplitz, Paul V. "A Conceptual Framework for Urban Planning Models." *Management Science*, Vol. 15, No. 6, pp. B-246-B-266, February 1969.

Liba, C. J. "Industrial Mineral Distribution by Unit Train." Presented at the Industrial Minerals Conference, Harrisburg, Pennsylvania, May 1-2, 1969.

Little, John D. C. "Mathematical Techniques: Mathematical Programming." *Operations Research for Public Systems*, ed. Philip M. Morse, Cambridge, Massachusetts: The M.I.T. Press, 1967, pp. 199-206.

Lowery, Ira S. *A Model of Metropolis*. Memorandum RM-4035-RC, Santa Monica, California: The RAND Corporation, August 1964.

Miesch, A. T., Connor, J. J., and Eicher, R. N. "Investigation of Geochemical Sampling Problems by Computer Simulation." *Quarterly of the Colorado School of Mines, Part A*, Vol. 59, No. 4, October 1964, pp. 131-148.

Morse, Philip M., and Bacon, Laura W. (editors). *Operations Research for Public Systems*. Cambridge, Massachusetts: The M.I.T. Press, 1967.

Naylor, Thomas H., Balintfy, Joseph L., Burdick, Donald S., and Chu, Kong. *Computer Simulation Techniques*. New York: John Wiley and Sons, Inc., 1966.

Nelson, Floyd J. "Simulation of a Mine Haulage Locomotive." Quarterly of the Colorado School of Mines, Part B, Vol. 59, No. 4, October 1964, pp. 831-847.

New York State Department of Commerce. Business Fact Book, 1963, Capital District: Part 2, Population and Housing. Albany, New York, 1963.

New York State Department of Public Works, Division of Construction. Public Works Specifications of 1962. New York, 1962.

O'Harrow, Dennis. The Urban Future. American Society of Planning Officials, February 1962.

Portland Cement Association. Concrete Information. "Proportioning Concrete Mixtures." Skokie, Illinois, 1967.

Quarterly of the Colorado School of Mines. "International Symposium, Applications of Statistics, Operations Research, and Computers in the Mineral Industry - Part A." Vol. 59, No. 4, October 1964.

Raser, John R. Simulation and Society: An Exploration of Scientific Gaming. Boston, Massachusetts: Allyn and Bacon, Inc., 1969.

Riley, Charles M. Our Mineral Resources. New York: John Wiley and Sons, Inc., 1959.

Schellie, Kenneth L., and Rogier, David A. Site Utilization and Rehabilitation Practices for Sand and Gravel Operations. National Sand and Gravel Association, Silver Springs, Maryland, 1963.

Schlager, Kenneth J. "A Land Use Plan Design Model." Journal of the American Institute of Planners, May 1965, pp. 103-111.

Shubik, Martin. "Simulation of the Industry and the Firm." American Economic Review, Vol. 50, No. 5, December 1960, pp. 908-919.

Socio-Economic Planning Sciences, ed. Sumner N. Levine, Vol. 1, No. 3. New York: Pergamon Press, July 1968.

Thieme, W. I. "Gravel Land Zoning and Rehabilitation." Presented at the Michigan Highway Conference, Grand Rapids, Michigan, March 6, 1968.

Thieme, W. I. "The Present Status of Reclamation in the Sand and Gravel Industry." Presented at the 53rd Annual Convention of the National Sand and Gravel Association, New York, New York, January 27, 1969.

Tocker, K. D. The Art of Simulation. Princeton, New Jersey: D. Van Nostrand Co., 1963.

United States Bureau of Mines. Minerals Yearbook, Volume I. Washington, D. C.: Government Printing Office, 1963.

U. S. News and World Report. "The Way the U. S. Is Growing - What It Means." January 13, 1964, pp. 82-85.

Wallace, William A., Dunn, James R., and Bishko, Donald. "Planning for Common Mineral Resources: A Computer Simulation Approach." Presented at the Fall Meeting of the Society of Mining Engineers, Minneapolis, Minnesota, September 18-20, 1968.

Wallace, William A., Dunn, James R., and Bishko, Donald. "Planning For Non-Renewable Mineral Resources: A Preliminary Model." Presented at the Institute of Management Sciences 1966 American Meeting, Dallas, Texas, February 16-19, 1966.

Watt, Kenneth E. F. "Computers and the Evaluation of Resource Management Strategies." American Scientist, 52, 1964, pp. 408-418.

Willis, Byron H. "The Software Challenge: Urban Planning and Computer Technology." Software Age, November 1967, pp. 18-23.

Wolfe, Harry B., and Ernst, Martin L. "Simulation Models in Urban Planning." Operations Research for Public Systems, ed. Philip M. Morse. Cambridge, Massachusetts: The M.I.T. Press, 1967, pp. 49-81.

Zwick, Charles J. "Systems Analysis and Urban Planning." Presented at the Conference on Information Systems and Programs for Urban Planning. University of Southern California, June 7, 1963.

APPENDIX A

USER'S GUIDE

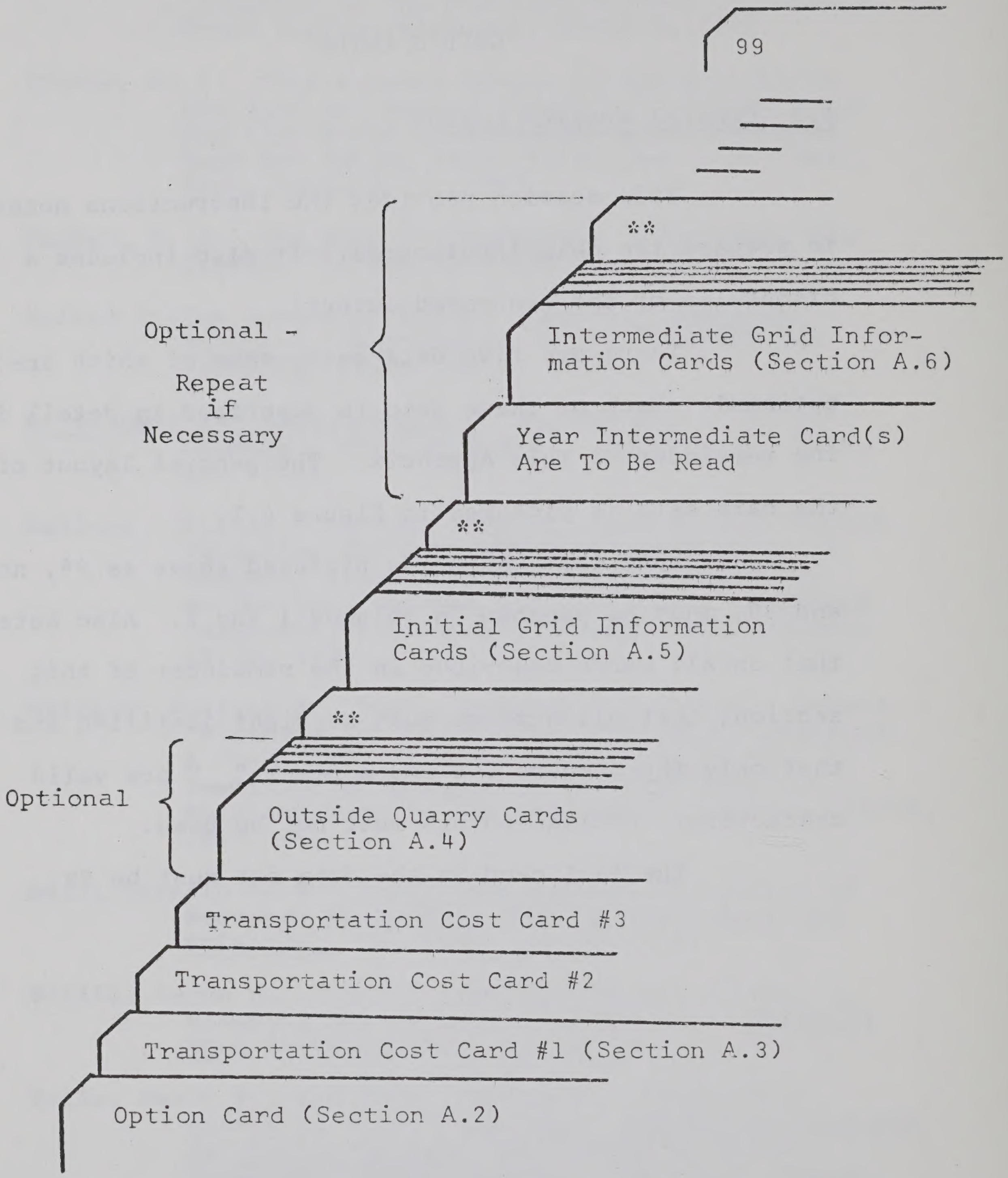
A.1 General Program Layout

This section provides the instructions necessary to prepare the data input cards. It also includes a discussion of the generated output.

There are five data sets, some of which are optional. Each of these sets is described in detail in the remainder of this Appendix. The general layout of the data sets is pictured in Figure A.1.

Note that the cards pictured above as **, nn, and 99, must be punched in columns 1 and 2. Also note that on all cards described in the remainder of this section, that all numbers must be right justified and that only the numbers 0-9 and a blank "__" are valid characters. Decimal points must not be used.

The last card in the data set must be 99.


99
**
Optional -
Repeat
if
Necessary
Intermediate Grid Information Cards (Section A.6)
Year Intermediate Card(s) Are To Be Read
**
Initial Grid Information Cards (Section A.5)
**
Optional
Outside Quarry Cards (Section A.4)
Transportation Cost Card #3
Transportation Cost Card #2
Transportation Cost Card #1 (Section A.3)
Option Card (Section A.2)

DATA CARD LAYOUT

FIGURE A.1

A.2 Option Card

The model user has certain options under which a simulation run may be included. The details and the format of the option card which must be the first card in the data set, is described below.

Card Column	Identification	Explanation
1, 2	Maximum year	The number of years the simulation is to proceed (a number from 1 to 98).
3	Allocation option	This option concerns how often a quarry will be assigned to a work-in-process or development forecasted. The user is permitted three choices: 1= To allocate each period. This option is the most time consuming from an operational standpoint but is the most realistic from the model viewpoint. It essentially says that users will contract material from a supplier for no longer than 1 year. At the end of the year, if the project is not completed, a new supplier will be assigned. 2= Allocate whenever a new quarry is added. This option is more efficient from an operational standpoint than no. 1. It essentially says that once a quarry is assigned (on a lowest cost basis) to a project that it will remain the lowest cost quarry and will therefore be reassigned as in option 1. Only, when a new quarry is added to the system (whose

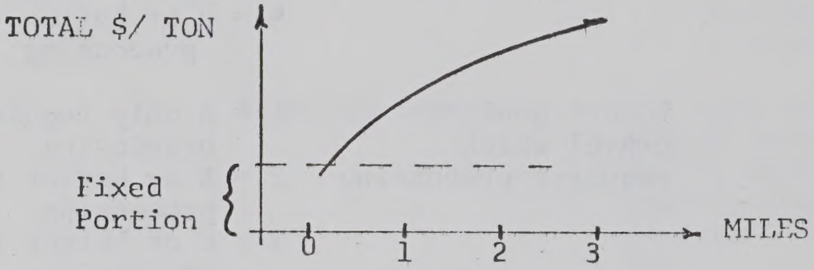
		cost could be lower than on assigned quarry) will reallocation take place. 3= Allocate only when present supplier can no longer meet its demands. This option is the most efficient from an operational standpoint. However, a new quarry added to the system will not be competitive since new assignments do not take place.
4	Output option for quarry usage	Does the user want the yearly production of each quarry printed each year. 0 = no, 1 = yes
5, 6	Planning horizon	How many years in the future should operations consider in the determination of the calculations for the centers of demand (a number from 1 to 98).
7	Zoning law to be supplied if grid is not zoned	In many cases, grids will not be zoned. In this case, the model user can test the model by supplying zoning laws 1 through 7 to determine the affect of various zoning schemes. (See col. 7, grid information input card for an explanation of the zoning laws). (A number from 1-7).
8 - 11	Horizontal grid conversion factor (in miles/100)	The number of miles horizontally over which 1 grid extends (i.e., the number of miles between successive integer columns). (e.g. 1234 = 12.34 miles).
12 - 15	Vertical grid conversion factor (in miles/100)	The number of miles vertically over which 1 grid extends (i.e., the number of miles between successive integer rows). (e.g., __75=.75 miles)

16 - 19	Straight line to road distance conversion factor	The number which converts a straight line distance of one mile to a road distance (e.g., _147 = 1.47 road miles).
Note:	The conversion factor usually used is 1 mile as the crow flies = 1.47 road miles	
20	Lowest quality sand which requires processing	1 = a only requires processing 2 = b or better requires processing 3 = c or better requires processing 4 = d or better requires processing
21	Lowest quality gravel which requires processing	1 = A only requires processing 2 = B or better requires processing 3 = C or better requires processing 4 = D or better requires processing 5 = Item #3 or better requires processing 6 = Item #4 or better requires processing
Note:	See columns 17 and 18 for a discussion of quality classifications	
22 - 25	The fixed portion of the transportation cost in collars and cents.	A number from 0 to 9999 (e.g., _134 = $1.34)
Note:	See transportation cost curve cards	
26, 27	Life of new processing plant in years	A number from 1 - 99 (e.g., 25 = 25 years)

28 - 30	% unprocessed sand and gravel which is required from a quarry	If the construction site does not go through a highly populated area, the total unprocessed sand and gravel required from a quarry is reduced. For example, if 100 tons are required, and __30 = 30%is punched on card, 30 tons of unprocessed material must be obtained from a quarry supplier.

A.3 Transportation Cost Curve

A typical transportation cost curve looks as follows.



The fixed portion (which includes loading and unloading costs), is determined by the user and shown on the option card, columns 22 - 25. To this cost is added the variable transportation costs which are given in discrete values on the three transportation cost curve cards described in this section. Each cost is given as a 3 column number and is interpreted as dollars and cents. For example 123 = $1.23/ton. The cards are laid out as follows.

Card 1

Col. (Cost)	Mileage
1 - 3	< 1
4 - 6	2
7 - 9	3

⋮

76 - 78	25

Card 2

1 - 3	26
4 - 6	27
.	
.	
.	
76 - 78	51

Card 3

1 - 3	52
4 - 6	53
.	
.	
.	
34 - 36	63

It is assumed that the variable cost curve is horizontal after a distance of 64 miles is attained. It must be noted that these cost curves apply only to materials shipped within the grid system (hence - by truck). In reality, it is very unusual to truck for distances greater than 50 miles. Therefore, this restriction is not critical. Transportation cost from outside the grid system is shown in the next section.

A.4 Outside Quarry Information Card

Very often it is not convenient to extend the range of the grid system to include all quarry suppliers. If this is the case, the user may include up to 998 outside quarries, each with its own unique identifying number. This set of cards (if included) must be in serial order, starting from outside quarry no. 1. The format of these cards is described below.

Card Column	Identification	Explanation
1 - 3	Number of outside quarry	A number from 1 to 999
Note:	All other information on the card pertains to the quarry whose number is in columns 1 to 3	
4	Type of quarry	1 = crushed stone 2 = unprocessed sand and gravel 3 = processed sand and gravel
5	Quality of material	(See columns 18 and 19 of grid information card)
6 - 9	Total cost to unloading point or to grid system (in dollars and cents/ton)	If the outside quarry is supplying the grid system by rail or barge, this is the cost to the unloading point. If, however, the outside quarry is supplying the grid system by road, it is the cost to the grid closest to the outside quarry through which the road from the outside quarry would pass. (A number from 0 to 9999) (e.g., _527 = $5.27/ton).
10-12	Row unloading point	The row designation of the grid which is the unloading point or the grid nearest to the outside quarry.
13 - 15	Column unloading point	The column designation of the grid which is the unloading point or the grid nearest to the outside quarry.

A.5 Grid Information Input Card

This section describes in detail the format of the cards describing the grids included within the grid system.

Card Column	Identification	Explanation
1 - 3	Grid row	The row of the grid whose characteristics are described on the remainder of the card (A number from 1 to 998).
4 - 6	Grid column	The column of the grid (A number from 1 to 998).
Note:	All other information on this card pertains to the grid whose row and column are designated in columns 1 - 6.	
7	The zoning law affecting the grid as it pertains to quarrying (removing material from the ground) and processing.	0 = no zoning 1 = quarrying not permitted 2 = quarrying permitted, processing permitted 3 = Same as #2 (under special permit 4 = quarrying not permitted, processing permitted 5 = Same as #4 (under special permit) 6 = quarrying permitted, processing not permitted 7 = Same as #6 (under special permit)
Note:	A blank is converted to a 0.	
Note:	Special permit zoning laws exist in reality but are not implemented in this research.	
8	Is the grid occupied?	0 = no 1 = yes
9	Is the grid a quarry (are aggregates being removed from the ground) and/or a processing plant?	0 = not quarry, not processing plant 1 = not quarry, yes processing plant 2 = yes quarry, not processing plant 3 = yes quarry yes processing plant

10	Is grid a potential quarry (i.e., does it contain aggregates worth mining?)	0 = no 1 = yes
Note:	A computer restriction is that the grid cannot be both a quarry and a potential quarry.	
Note:	Columns 11 - 36 pertain only if the grid is a quarry or a potential quarry.	
11, 12	Number designation of owner of quarry or potential quarry.	A number from 0 - 99
Note:	If potential land is unowned or owner is not known, the number 0 makes it available for anyone desiring to use it.	
13	Type quarry or potential quarry	If potential quarry: 1 = crushed stone 2 = sand and gravel If quarry: 1 = crushed stone 2 = sand and gravel (not being used as an intermediate processing plant) 3 = sand and gravel (being used as an intermediate processing plant) 4 = sand and gravel (which uses an intermediate processing plant)
14 - 16	% sand (if a processed sand and gravel quarry or potential quarry)	Number from 0 to 100 (e.g., _53 = 53%)
17	Quality fine aggregate	1 = a 2 = b 3 = c 4 = d 7 = run of bank

18	Quality coarse aggregate	1 = A 2 = B 3 = C 4 = D 5 = Item 3 6 = Item 4 7 = run of bank
Note:	Qualities are New York State Specifications. An incorrect character defaults to #7.	
19 - 22	Remaining or expected life (in thousands of tons) of the quarry or potential quarry).	Number from 0 to 9999 (e.g., _917 = 917,000 tons)
23 - 26	Maximum yearly output of quarry or potential quarry (in thousands of tons)	Number from 0 to 9999 (e.g., __60 = 60,000 tons)
27 - 30	Establishment cost (in thousands of dollars) if grid is a quarry without a processing plant, or a potential quarry.	Number from 0 to 9999 (e.g., _500 = $500,000)
Note:	This cost includes cost of processing plant, removing overburden, access roads, etc.	
	or	
	Amortization cost of initial investment (in dollars and cents/ton) if grid is a quarry with a processing plant.	Number from 0 to 9999 (e.g., _132 = $1.32)
Note:	The amortization cost is essentially the initial cost of establishing the quarry divided by the initial life of the quarry.	

31 - 34	Cost to mine and process per ton (in dollars and cents) for quarry or potential quarry.	Number from 0 to 0000 (e.g., _724 = $7.24)
	Note: Profits may be included in this figure. If they are, they should be included in the all other quarries and potential quarries also.	
35, 36	Life processing plant in years	If grid is a quarry and a processing plant, its remaining life (a number from 0 to 99)
37	Is a development forecasted	0 = no 1 = yes
38, 39	Year development forecasted will start	If grid is a development forecasted, the year it will start (a number from 0 to 99)
40	Is work in process	At the time of the initial data input, is work in process 0 = no, 1 = yes
	Note: Columns 41 - 79 are pertinent only if the grid is a work-in-process or a development forecasted.	
41 - 44	Processed sand and gravel to completion (in thousands of tons)	A number from 0 to 9999 (e.g., 1234 = 1,234,000 tons)
45	Minimum quality processed sand and gravel required.	(See column 18 for quality classification)
46 - 48	% sand if processed sand and gravel is required.	A number of 0 to 100 (e.g., __33 = 33%

49 - 52	Unprocessed sand and gravel to completion (in thousands of tons)	A number from 0 to 9999 (e.g., 1682 = 1,682,000 tons)
53	Minimum quality unprocessed sand and gravel required	(See column 18 for quality classification)
54 - 57	Crushed stone to completion (in thousands of tons)	A number from 0 to 9999 (e.g., 397 = 397,000 tons)
58	Minimum quality crushed stone required	(See column 18 for quality classification)
59, 60	Years to completion	If grid is a work-in-process or a development forecasted, how many years it will take to complete it (a number from 0 to 99).
62 - 64	Row processed sand and gravel supplier	At the time of the study, the actual supplier to a work-in-process or development forecasted might be known. If so, the row and column of that supplier can be read in as input.
65 -67	Column processed sand and gravel supplier	
68 - 70	Row unprocessed sand and gravel supplier	
71 - 73	Column unprocessed sand and gravel supplier	If the quarry supplier is from outside the grid system, the row must be 999 and the column contain the number of the outside supplier.
74 - 76	Row crushed stone supplier	
77 - 79	Column crushed stone supplier	An incorrect row and/or column designation acts the same as if a quarry is not assigned. (numbers from 1 to 998 with the exception noted above)

Although it is not necessary to have a card for each quarry within the system, the cards must be sequenced by row, starting with the lowest numbered column in the lowest numbered row.

A.6 Intermediate Grid Information

As shown in section A.5, grids can be multiply-defined (for example they can be both a quarry and a development forecasted). However, due to programming restrictions, they cannot be two developments forecasted or a work-in-process and a development forecasted, one scheduled to start in period N_1 and another in N_2 (where $N_1 < N_2$). In real life this case often arises.

Therefore, when it is known in advance that a grid is to be more than one development forecasted, intermediate cards describing the all developments forecasted beyond the first can be read into the model. This is done by preparing a "time card" with the year the new development (s) forecasted are to read in (punched in columns 1 and 2 - see section A.1) followed by the card(s) describing the developments to be started in that year. These cards are followed by a card with "**" punched in columns 1 and 2.

This set of cards also allows the zoning law affecting any grid to be changed at the point in time designated by the "time card".

If more than 1 intermediate grid data card is read in a given time period (as designated by the time card), the cards must be in the same order perscribed by the grid information cards.

Card Column	Identification	Explanation
1 - 3	Grid row	See grid information card (Section A.5)
4 - 6	Grid column	Columns 1 - 6.

7		Zoning laws	If the zoning law is to be changed, a number from 1 to 7 (see column 7, grid information card) must be included. A blank designates no change in zoning law.
8		unused	
9		Is grid occupied	0 = no 1 = yes
10 - 36		unused	
37		Is a development forecasted	0 = no 1 = yes
	Note:	The remaining information on this card pertains only if a development is forecasted.	
38 - 40		unused	
41 - 60		same as columns 41 - 60 on grid information card (see section A.5)	
61 - 80		unused	
	Note:	It must be noted that any grids which are to have developments forecasted read in on intermediate grid cards must have all present work completed.	

A.7 Sample Output

The following two pages are an example of output generated during one year of a simulation run.

```
                   CUMULATIVE TOTALS UP TO AND INCLUDING YEAR   4

                            PROCESSED S&G       UNPROCESSED S&G       CRUSHED STONE

CUMULATIVE DOLLARS            16,110,365            8,905,032            13,366,586

CUMULATIVE TON-MILES          65,071,600           52,035,875            63,799,000

CUMULATIVE TONS                6,524,200            4,493,875             4,493,250

                  CUMULATIVE TRANSPORTATION DOLLARS =   13,487,520

                  CUMULATIVE TONS FROM OUTSIDE GRID SYSTEM =       123,000

                  CUMULATIVE COST MATERIAL FROM OUTSIDE GRID SYSTEM =       375,950

                  CUMULATIVE DOLLARS =   38,757,933

                  CUMULATIVE TON-MILES (WITHIN GRID SYSTEM ONLY) = 180,906,475

                  CUMULATIVE TONS =   15,634,325

                  CUMULATIVE TONS WASTED AT ZONED OUT QUARRY SITES =            0

                  CUMULATIVE TONS WASTED AT ZONED OUT POTENTIAL QUARRIES =            0

                  CUMULATIVE MATERIAL WASTED =            0
```

```
                    MATERIAL USED AT QUARRIES DURING    YEAR   4

                                NEW QUARRIES

                        GRID          TONS MATERIAL

                       52,   61          200,000
```

```
                              BEGIN YEAR    4

          AS A RESULT OF ACTIVITIES OF THE PREVIOUS YEAR, THE
          FOLLOWING CHANGES ARE MADE IN THE GRID CONFIGURATION


          GRID    36,    42 IS WEIGHTED GEOMETRIC CENTER FOR PROCESSED SAND AND GRAVEL
          GRID    37,    42 IS WEIGHTED GEOMETRIC CENTER FOR UNPROCESSED SAND AND GRAVEL
          GRID    36,    42 IS WEIGHTED GEOMETRIC CENTER FOR CRUSHED STONE


          POTENTIAL QUARRY IN GRID    52,    61 IS ESTABLISHED AS A QUARRY

          QUARRY IN GRID    54,    60 HAS BEEN REMOVED FROM SYSTEM.
          UNUSED MATERIAL IS            0 TONS.


          YEARLY DEMAND ON QUARRY IN GRID    50,    48 HAS EXCEEDED MAXIMUM YEARLY OUTPUT

          OUTSIDE QUARRY     1 HAS BEEN ASSIGNED TO WIP IN GRID    13,    60.

          OUTSIDE QUARRY     1 HAS BEEN ASSIGNED TO WIP IN GRID    17,    56.




                                     TOTALS FOR YEAR    4

                         PROCESSED S&G        UNPROCESSED S&G        CRUSHED STONE

    TOTAL DOLLARS           4,597,590             2,229,628             3,556,087

    TOTAL TON-MILES        18,970,100            12,495,625            16,506,500

    TOTAL TONS              1,864,600             1,259,125             1,210,250

               TOTAL TRANSPORTATION DOLLARS =     3,608,600

               TOTAL TONS FROM OUTSIDE GRID SYSTEM =        31,000

               TOTAL COST MATERIAL FROM OUTSIDE GRID SYSTEM =        89,250

               TOTAL DOLLARS =    10,472,555

               TOTAL TON-MILES (WITHIN GRID SYSTEM ONLY) =  47,972,225

               TOTAL TONS =     4,364,975

               TOTAL TONS WASTED AT ZONED OUT QUARRY SITES =              0

               TOTAL TONS WASTED AT ZONED OUT POTENTIAL QUARRIES =              0

               TOTAL MATERIAL WASTED =          0
```

APPENDIX B

PROGRAMMER'S GUIDE

The purpose of this Appendix is to provide information which, when used in conjunction with the Detailed Flow Diagrams (Appendix C) and the documented program itself (Appendix D), will enable a competent IBM/360 Assembly Language Programmer to make changes and/or additions to the computerized model.

B.1 General Information

The computer program may be assembled as four separate assemblies, in which case dummy sections of COMMON must be included with MINESUBR, BEGINIT, and MINEDF. The actual COMMON must be included at the end of MINEINPT. If program is run from object decks prepared by these separate assemblies, MINEINPT must be included last and an entry reference to MINEINPT given in the control cards.

If the model is run as one job, MINEINPT must be last with COMMON at the very end.

B.2 Matrix Configuration

Information concerning each of the grids is stored in a matric (called MATRIX), each grid requiring 84 bytes of core storage. The layout of the grid is given below; each characteristic is expressed as a displacement (in bytes) from the first byte in the grid.

Location (Displacement)	Length (in bytes)	Identification	Explanation
+0	2	Row	The row of the matrix*
+2	2	Column	The column of the matrix
+4	1	Zoning law	Bits: 0 = no, 1 = yes X X X X X X X X Processing allowed Quarrying allowed Unzoned Special permit
+5	1	Quarry identification	Bits: 0 = no, 1 = yes X X X X X X X X Is it a processing plant Is material being removed Is material processed elsewhere Does owner wish to self preserve Is it used as an intermediate processing point Is is crushed stone Is it sand and gravel Has it been zoned out

---

* All numbers are expressed in true binary (or integer) form.

+6	1	Potential quarry identification	Bits { 0 = no, 1 = yes } X X X X X X X X Has it been zoned out Is it sand and gravel Is it crushed stone Is it potential quarry

Note: The following information is pertinent only if the grid is a quarry or a potential quarry.

+7	1	Owner	An identifying number either given on the input card or generated by the model.
+8	4	Life of quarry	Expressed in tons
+12	4	Maximum yearly output	Expressed in tons
+16	4	Establishment cost	If grid is a quarry without a processing plant or a potential quarry, the establishment cost is given in dollars.
+20	2	Cost to mine and process	Expressed in cents/ton
+22	2	Quality fine aggregate	(See N.Y.S. Specifications) a = 11111111 b = 11111110 c = 11111100 d = 11111000 Bank run = 11000000

+23	1	Quality coarse aggregate	A = 11111111 B = 11111110 C = 11111100 D = 11111000
		Gravel only	Item 3 = 11110000 Item 4 = 11100000 Bank run = 11000000
+24	1	% sand (if sand and gravel)	Expressed as a whole number (i.e., 35 = 35%)

Note: The following items are pertinent if the grid is a work-in-process (WIP) or a development forecasted (DEVFO).

+25	1	Is a development forecasted	0 = no 1 = yes
+26	1	Year DEVFO will start	Expressed as a number (from 1 to 98)
+27	1	Years to completion	The number of years it will take to complete the DEVFO or WIP
+28	4	Processed sand and gravel to completion (in tons)	The amount of material required to complete the project.
+32	4	Unprocessed sand and gravel to completion (in tons)	" " "
+36	4	Crushed stone to completion (in tons)	" " "
+40	1	Quality processed S & G required	(See +23)
+41	1	% Sand to completion	Of total amount of sand and gravel required, that amount (as a %) which is sand.

+42	1	Remaining life processing plant (in years)	If grid is a quarry with a processing plant, the remaining life of that plant in years.
+43	1	Is work-in-process	0 = no 1 = yes
+44	1	Quality unprocessed S&G required	(See +23)
+45	1	Is grid occupied	Can unprocessed sand and gravel be obtained at the site (0= no, 1 = yes)
+46	2	Amortization cost	If grid is a quarry, the fixed cost in cents/ton
+48	1	Quality crushed stone required	(See +23)
+49	1	If quarry supplier is outside grid system, type of quarry	X X X X X X X X 1 = processed S&G 1 = unprocessed S&G 1 = crushed stone
+50 +51	unused		
+52	4	Quarry or potential quarry chain address	(See chaining)
+56	4	Development forecasted chain address	" "
+60	4	Work-in-process chain address	" "
+64	4	Core address of processed sand & gravel supplier	If DEVFO or WIP

+68	4	Core address unprocessed sand & gravel supplier	If DEVFO or WIP
+72	4	Core address crushed stone supplier	" "
+76	4	Amount of material presently being used (in tons)	If grid is a quarry, its yearly usage
+80	4	Address intermediate point	If WIP is getting material from a quarry which is shipping to an intermediate point, the core address of the intermediate point.

B.3 Core Size Requirements

The amount of core required by the program itself is as follows:

Section	Characters (Bytes)
MINESUBR	2752
BEGINIT	2448
MINEDP	5688
MINEINPT	4592
TOTAL	15,480

To this (84 x number of grids must be added) + (16x number of outside quarries in excess of 10). In order to increase the number of outside quarries, the duplication factor on statement 3874 must be changed to be equal or greater than the required number. Similarly, to increase the number of grids, the duplication factor in statement 3907 must be changed to at least the actual number of grids included within the system.

B.4 Subroutines

Included in this section are the subroutines which are used by all sections of the program.

B.3.1 Subroutine Add Quarry to Quarry Chain (SRAQ)

This subroutine is responsible for two functions: 1) to add a quarry to the quarry chain by including its address in the chain, and 2) to provide it with an ownership identification if it is added because of demand requirements. (See flow diagram, Appendix C, page 16, and coding, Appendix D, statements 10-64).

B.3.2 Subroutine Add Potential Quarry to PQ Chain (SRAPQ)

B.3.3 " " Work-In-Process to WIP Chain (SRWIP)

B.3.4 " " Development Forecasted to DEVFO Chain (SRADEVFO)

These subroutines are responsible for setting the address pointers which will attach the item added to its proper chain. (See flow diagrams Appendix C, pp. 16-17, and source coding, Appendix D, statements 66-124).

B.3.5 Subroutine Delete Quarry from Q Chain SRDQ)

B.3.6 " " Potential Quarry from PQ Chain (SRDPQ)

B.3.7 " " Work-In-Process from WIP Chain (SRDWIP)

B.3.8 " " Development Forecasted from DEVFO Chain (SRDDEVFO)

When an item is removed from a chain, the entries within the chain must be relinked in order to keep the chain intact yet exclude the address of the deleted item. It is the responsibility of the above four subroutines to make the necessary addressing changes. (See flow diagrams, Appendix C, pp. 18-19, and source coding, Appendix D, statements 126-247).

B.3.9 Subroutine Determine Distance Between Two Points (SRDIST)

The subroutine determines the distance (in road miles) between any two points. Using the row and column coordinates of each of the points, the straight line distance is found and then converted to a road distance by multiplying by the proper conversion factor which is set by the user (See Appendix A, Section A.2).

The formula used to determine distance is given below

$$RD_{12} = \beta \sqrt{(r_1 - r_2)^2 + (C_1 - C_2)^2}$$

where

RD_{12} = road distance point 1 to point 2

β = conversion factor from straight line distance to road distance

r_i = row point 1

r_2 = row point 2

C_1 = column point 1

C_2 = column point 2

(See flow diagram, Appendix C, p. 20, and source coding, Appendix D, Statements 249-319).

B.3.10 Subroutine Determine Transportation Cost (SRTRCST)

This subroute determines the transportation cost (in dollars/ton) to ship material over a distance determined by SRDIST. The transportation cost curve is set by the user as explained in Appendix A, Section A.3. (See coding, Appendix D, Statements 321-356).

B.3.11 Subroutine For Determining Allowance On Existing Processing Plant (SRAOEPP)

As discussed in Chapter 4, Section 4.34, it is the responsibility of this subroutine to determine the allowance (based on age of existing plant) that an owner can deduct from the cost of establishing a plant at a new location. (See source coding, Appendix D, Statements 358-392).

B.3.12 Subroutine Weighted Geometric Center (SRWGC)

This subroutine determines the weighted geometric centers for processed sand and gravel, unprocessed sand and gravel, and crushed stone as discussed in Chapter 4, Section 4.35. (See source coding, Appendix D, Statements 464-646).

B.3.13 Subroutine Present Period Usage (SRPPU)

This subroutine determines the tons of processed sand and gravel, unprocessed sand and gravel, and crushed stone of required by a project during a given year. It is assumed that usage is divided evenly (by year) over the entire project length. (See source coding, Appendix D, Statements 808-846).

B.3.14 Subroutines CARDIN & LINEOUT

These subroutines are responsible for handling all input and output functions of the program. The input field INPUT and output field OUTLINE is set by the main program before calling CARDIN or LINEOUT. (See source coding, Appendix D, Statements 648-806).

APPENDIX C

DETAILED FLOW DIAGRAMS

The following flow diagrams contain in detail the logic of the computer model.

Block forms used are:

```
  ****Xi**********
 *               *
 *               *    Terminal Block
 *               *       Xi = Block identification
  ****************

 ******Xi***********
  *               *
   *             *    Input/Output Block
    *           *        Xi = Block identification
     ***********

 *****Xi***********
 *               *
 *               *    Operation or Decision Block
 *               *       Xi = Block identification
 *               *
 *               *
 *****************

 *****Xi***********
 *               *    A Called Subroutine
 *XXXXXXX   iiijj*       XXXXXXX = Subroutine name
 *               *           iii = Subroutine page
 *               *            jj = Entry block
 *****************                 identification

     *****
     *iii*            Off Page Conector
     * Xi*               iii = page
      * *                 Xi = block identification
       *                      on page iii

     ****
    *    *
    * Xi *            On Page Connector
    *    *               Xi = Block identification
     ****
```

Blocks may be named. If they are, the name (which appears over the left corner of the block) corresponds with the name of the Assembly Language instruction.

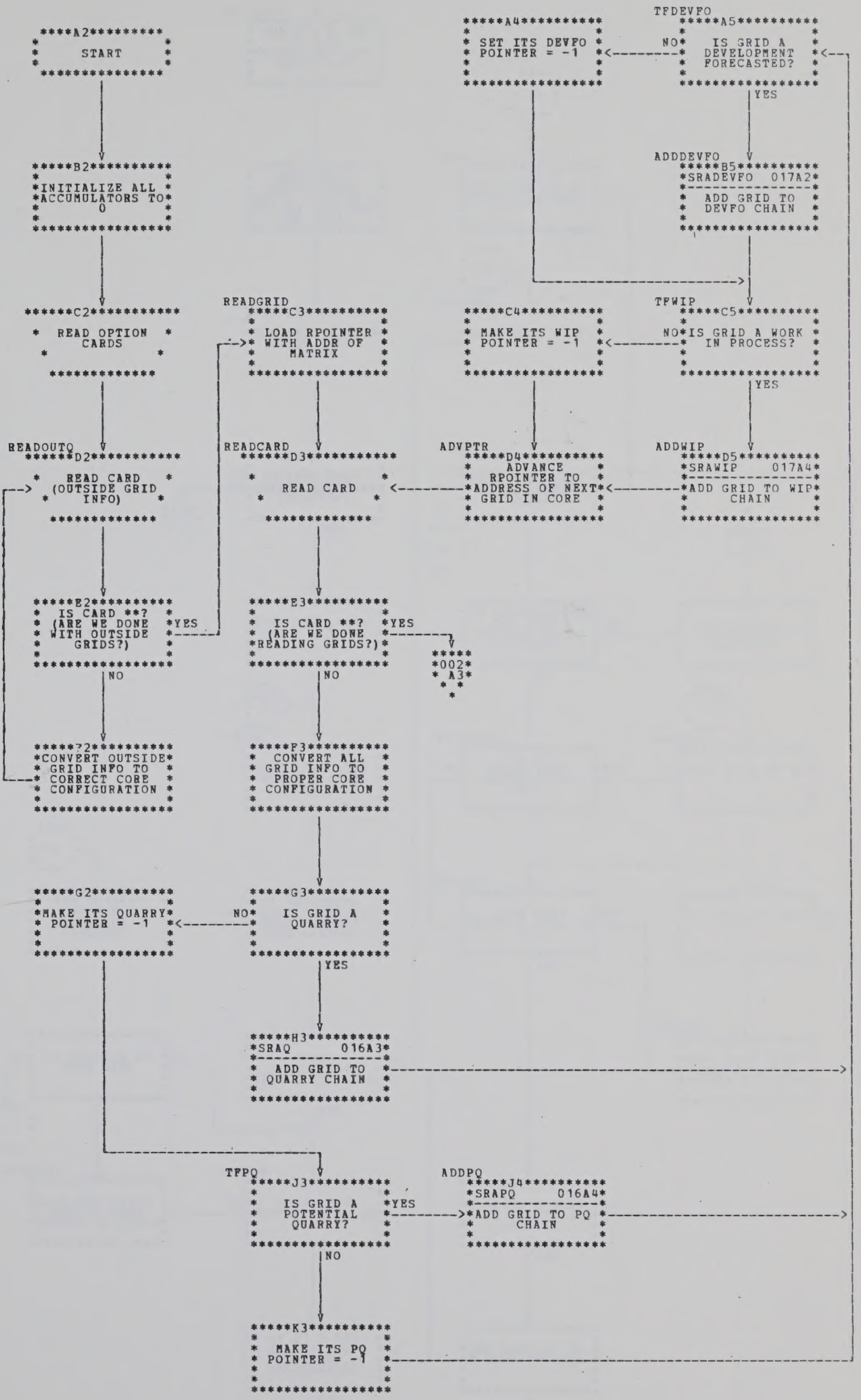
The following abbreviations are used throughout the flow diagrams:

ADDR	-	Address
AMORT	-	Amortization
DEVFO	-	Development forecasted
DEVFO(i)	-	Development forecasted whose address is in register i
E(LIFE)	-	Expected life
EST	-	Establishment
FLT PT	-	Floating point
GEOM	-	Geometric
INFO	-	Information
INTER POINT INTER PT IP	-	Intermediate processing plant
LARG	-	Largest
MAT'L	-	Material
NEG	-	Negative
PP PROC PLT	-	Processing Plant
PQ	-	Potential quarry
PQ(i)	-	Potential quarry whose address is in register i

Q	-	Quarry
Q(i)	-	Quarry whose address is in register i
Q1	-	Processed sand and gravel quarry
Q2	-	Unprocessed sand and gravel quarry
Q3	-	Crushed stone quarry
REGi	-	Register i
REQ'D	-	Required
S&G	-	Sand and Gravel
TRANS	-	Transportation
WIP	-	Work-in-process
WIP(i)	-	Work-in-process whose address is in register i
WGCCS	-	Weighted geometric center for crushed stone
WGCPSG	-	Weighted geometric center for processed sand and gravel
WGCUPSG	-	Weighted geometric center for unprocessed sand and gravel

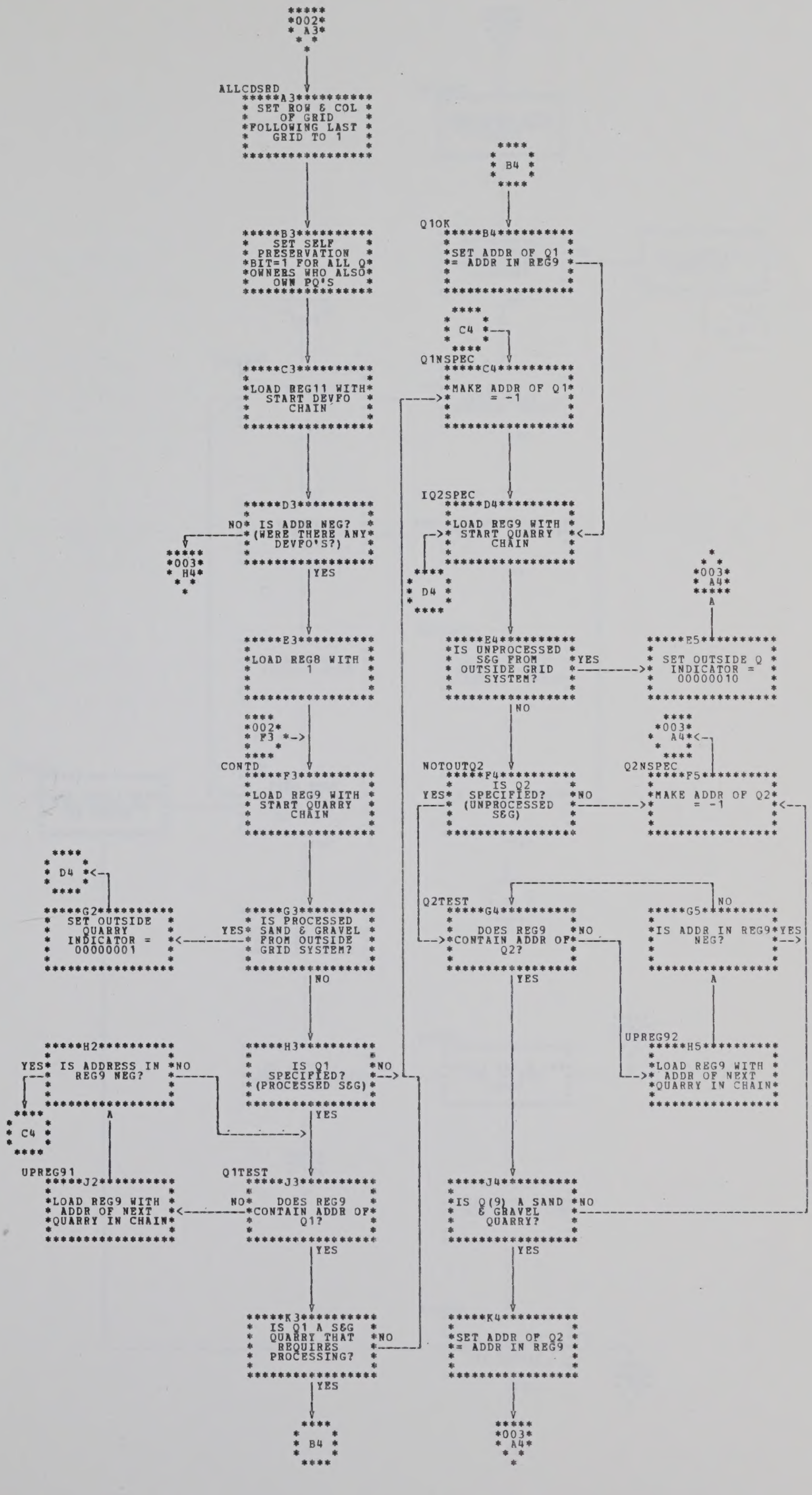
The flow diagrams on the following pages were prepared using the IBM Flowchart language. The page numbers are supplied by the flowcharting system and are the pages to which the body of the thesis refers.

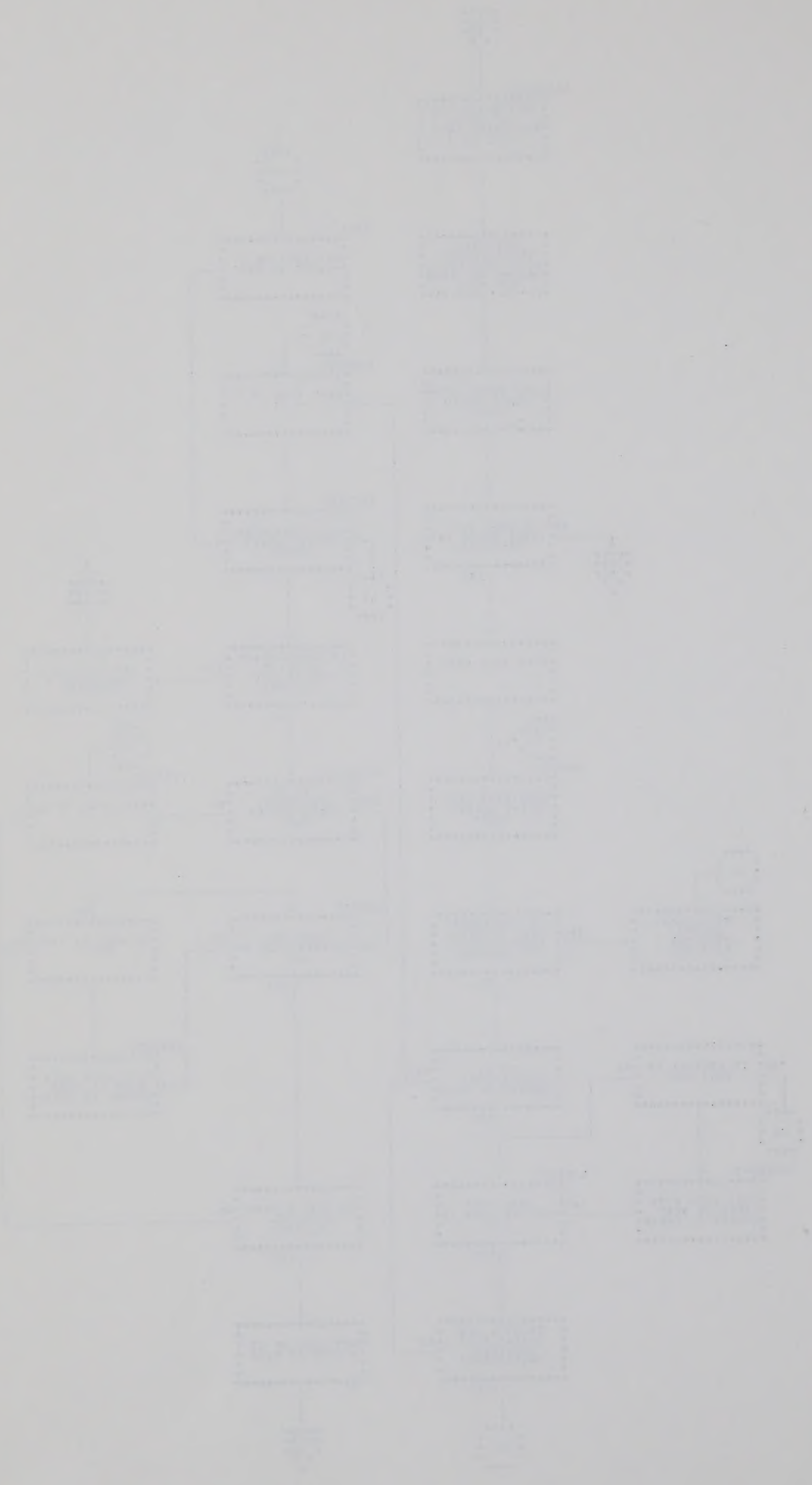
MAIN
INPUT SECTION
INITIAL CHAINING

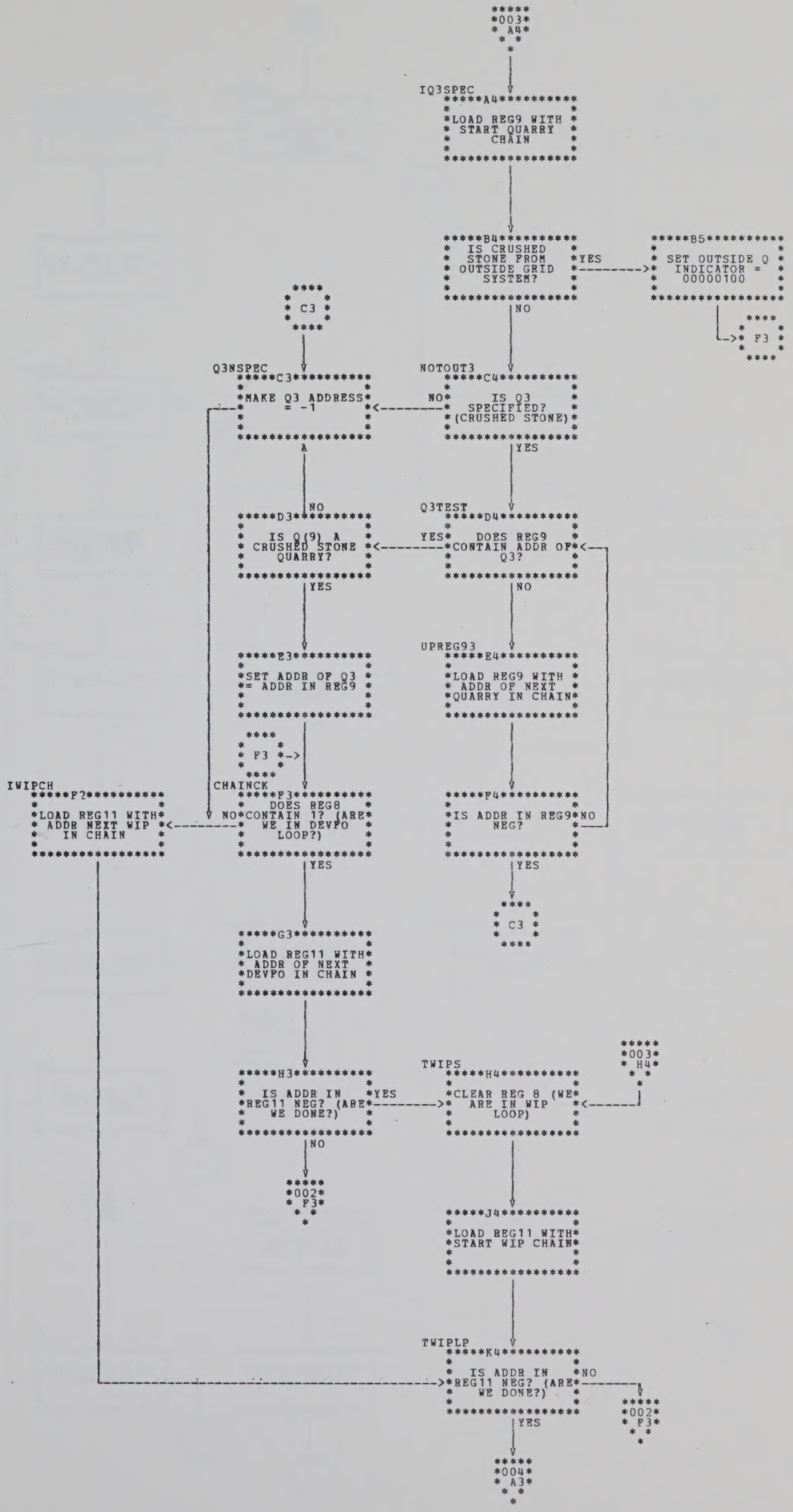

A2
START
B2
INITIALIZE ALL ACCUMULATORS TO 0
C2
READ OPTION CARDS
READOUTQ
D2
READ CARD (OUTSIDE GRID INFO)
E2
IS CARD **? (ARE WE DONE WITH OUTSIDE GRIDS?)
YES
NO
F2
CONVERT OUTSIDE GRID INFO TO CORRECT CORE CONFIGURATION
READGRID
C3
LOAD RPOINTER WITH ADDR OF MATRIX
READCARD
D3
READ CARD
E3
IS CARD **? (ARE WE DONE READING GRIDS?)
YES
002 A3
NO
F3
CONVERT ALL GRID INFO TO PROPER CORE CONFIGURATION
G3
IS GRID A QUARRY?
NO
YES
G2
MAKE ITS QUARRY POINTER = -1
H3
SRAQ 016A3
ADD GRID TO QUARRY CHAIN
TFPQ
J3
IS GRID A POTENTIAL QUARRY?
YES
NO
ADDPQ
J4
SRAPQ 016A4
ADD GRID TO PQ CHAIN
K3
MAKE ITS PQ POINTER = -1
TFDEVFO
A5
IS GRID A DEVELOPMENT FORECASTED?
NO
YES
A4
SET ITS DEVFO POINTER = -1
ADDDEVFO
B5
SRADEVFO 017A2
ADD GRID TO DEVFO CHAIN
TFWIP
C5
IS GRID A WORK IN PROCESS?
NO
YES
C4
MAKE ITS WIP POINTER = -1
ADVPTR
D4
ADVANCE RPOINTER TO ADDRESS OF NEXT GRID IN CORE
ADDWIP
D5
SRAWIP 017A4
ADD GRID TO WIP CHAIN

MAIN CONT'D

QUARRY ASSIGNMENTS AND ADDRESSING

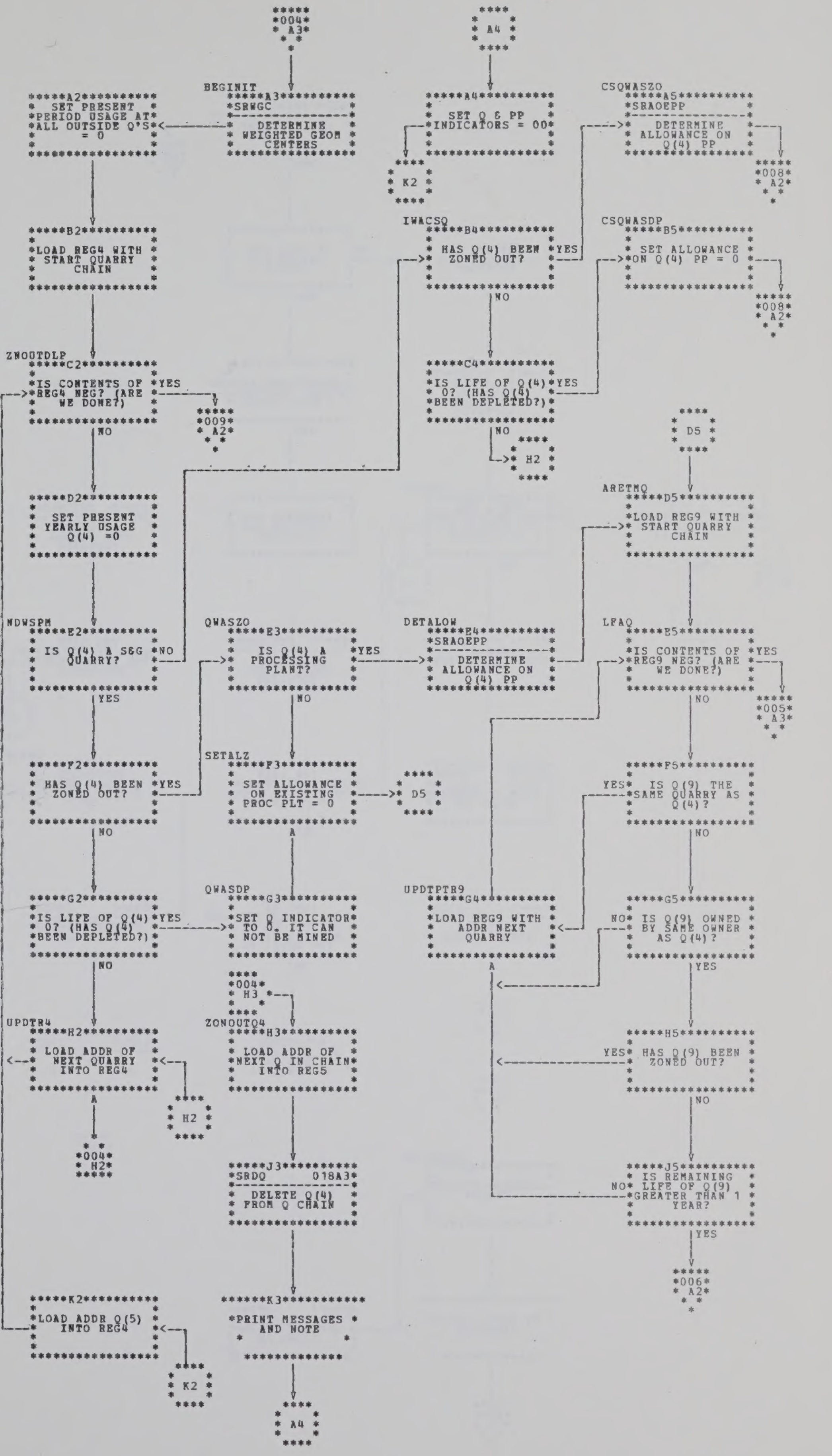

002 A3
ALLCDSRD
A3 SET ROW & COL OF GRID FOLLOWING LAST GRID TO 1
B3 SET SELF PRESERVATION BIT=1 FOR ALL Q OWNERS WHO ALSO OWN PQ'S
C3 LOAD REG11 WITH START DEVFO CHAIN
D3 IS ADDR NEG? (WERE THERE ANY DEVFO'S?)
NO
003 H4
YES
E3 LOAD REG8 WITH 1
002 F3
CONTD
F3 LOAD REG9 WITH START QUARRY CHAIN
G3 IS PROCESSED SAND & GRAVEL FROM OUTSIDE GRID SYSTEM?
YES
D4
G2 SET OUTSIDE QUARRY INDICATOR = 00000001
NO
H3 IS Q1 SPECIFIED? (PROCESSED S&G)
NO
YES
H2 IS ADDRESS IN REG9 NEG?
YES
NO
C4
UPREG91
J2 LOAD REG9 WITH ADDR OF NEXT QUARRY IN CHAIN
Q1TEST
J3 DOES REG9 CONTAIN ADDR OF Q1?
NO
YES
K3 IS Q1 A S&G QUARRY THAT REQUIRES PROCESSING?
NO
YES
B4
B4
Q1OK
B4 SET ADDR OF Q1 = ADDR IN REG9
C4
Q1NSPEC
C4 MAKE ADDR OF Q1 = -1
IQ2SPEC
D4 LOAD REG9 WITH START QUARRY CHAIN
D4
E4 IS UNPROCESSED S&G FROM OUTSIDE GRID SYSTEM?
YES
NO
003 A4
A
E5 SET OUTSIDE Q INDICATOR = 00000010
NOTOUTQ2
F4 IS Q2 SPECIFIED? (UNPROCESSED S&G)
YES
NO
003 A4
Q2NSPEC
F5 MAKE ADDR OF Q2 = -1
Q2TEST
G4 DOES REG9 CONTAIN ADDR OF Q2?
NO
YES
G5 IS ADDR IN REG9 NEG?
NO
YES
A
UPREG92
H5 LOAD REG9 WITH ADDR OF NEXT QUARRY IN CHAIN
J4 IS Q(9) A SAND & GRAVEL QUARRY?
NO
YES
K4 SET ADDR OF Q2 = ADDR IN REG9
003 A4

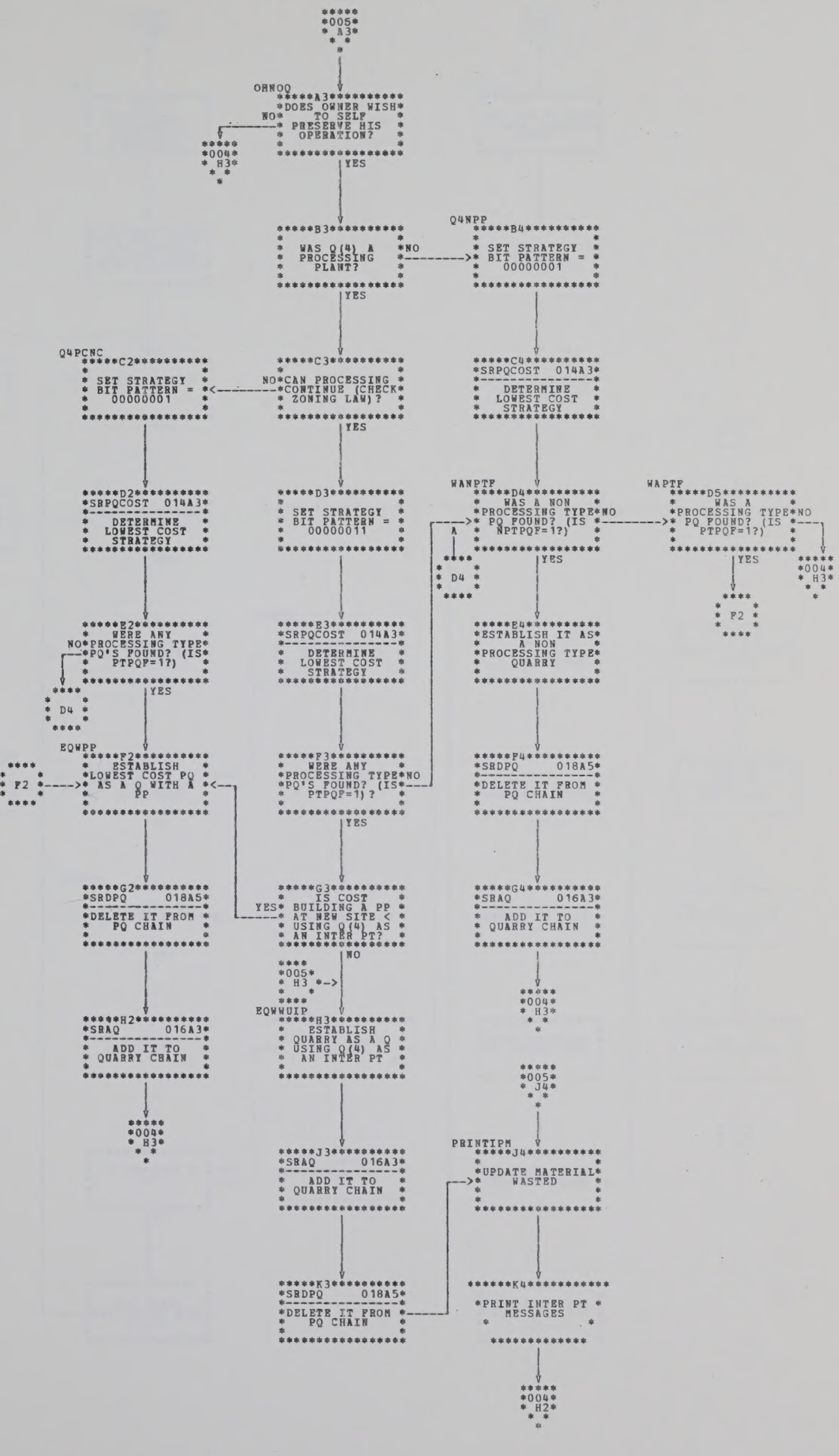



003 A4
IQ3SPEC
A4 LOAD REG9 WITH START QUARRY CHAIN
B4 IS CRUSHED STONE FROM OUTSIDE GRID SYSTEM?
YES
B5 SET OUTSIDE Q INDICATOR = 00000100
F3
NO
C3
NOTOUT3
C4 IS Q3 SPECIFIED? (CRUSHED STONE)
NO
Q3NSPEC
C3 MAKE Q3 ADDRESS = -1
A
YES
Q3TEST
D4 DOES REG9 CONTAIN ADDR OF Q3?
YES
NO
D3 IS Q(9) A CRUSHED STONE QUARRY?
NO
YES
E3 SET ADDR OF Q3 = ADDR IN REG9
UPREG93
E4 LOAD REG9 WITH ADDR OF NEXT QUARRY IN CHAIN
F4 IS ADDR IN REG9 NEG?
NO
YES
C3
F3
CHAINCK
F3 DOES REG8 CONTAIN 1? (ARE WE IN DEVFO LOOP?)
NO
IWIPCH
F2 LOAD REG11 WITH ADDR NEXT WIP IN CHAIN
YES
G3 LOAD REG11 WITH ADDR OF NEXT DEVFO IN CHAIN
H3 IS ADDR IN REG11 NEG? (ARE WE DONE?)
YES
NO
002 F3
003 H4
TWIPS
H4 CLEAR REG 8 (WE ARE IN WIP LOOP)
J4 LOAD REG11 WITH START WIP CHAIN
TWIPLP
K4 IS ADDR IN REG11 NEG? (ARE WE DONE?)
NO
002 F3
YES
004 A3

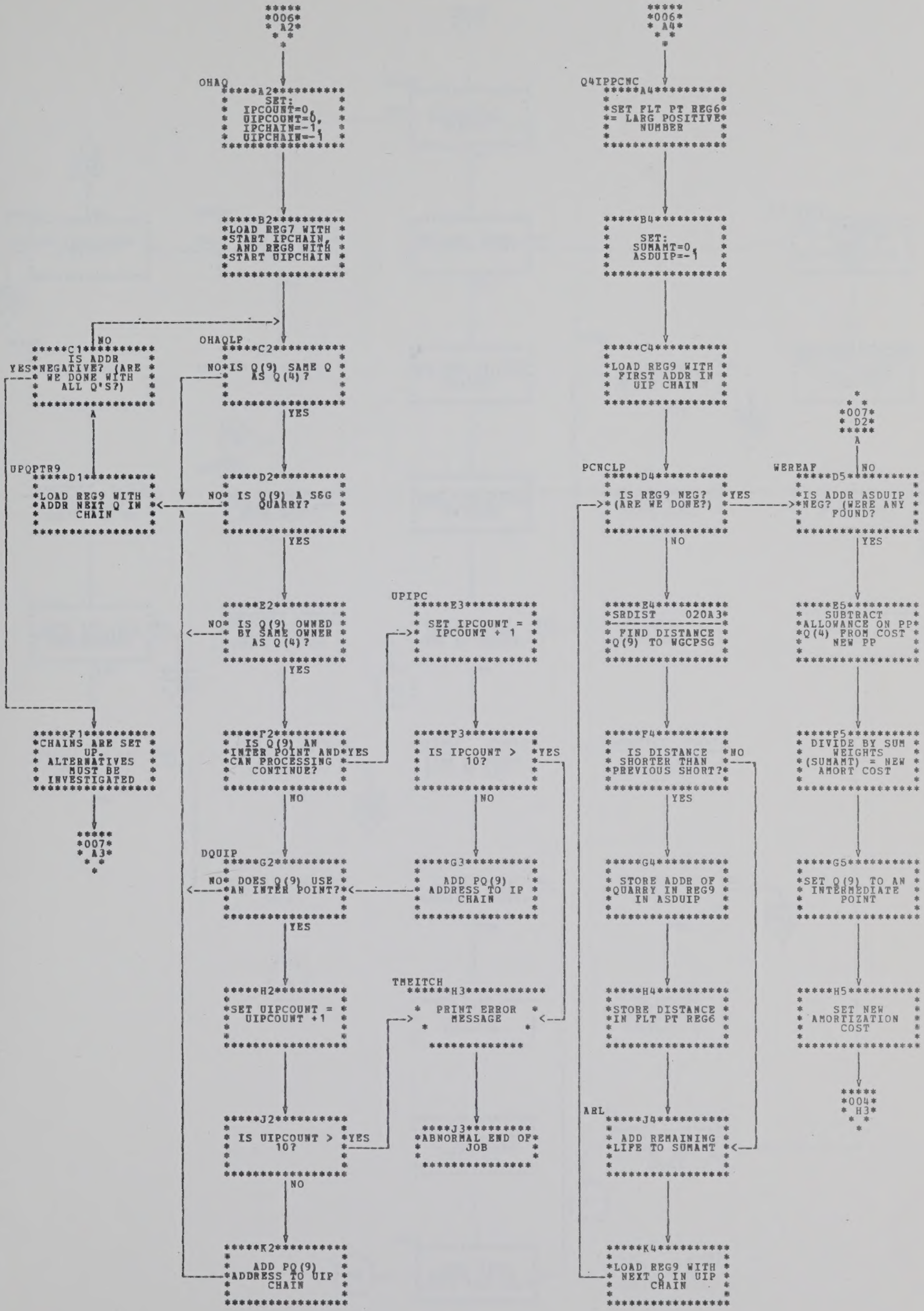
[illegible]

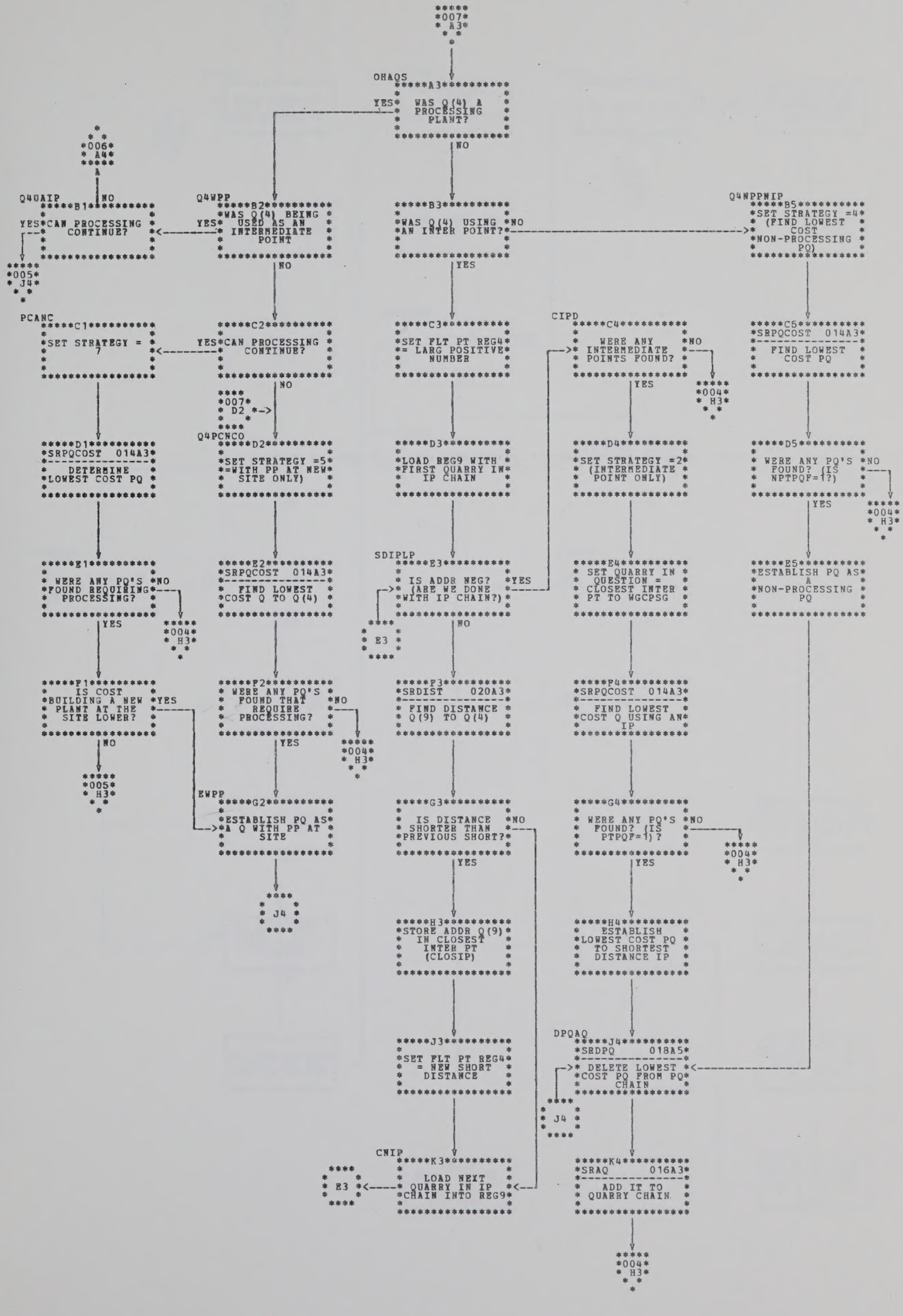
PAGE 4


004 A3
A4
A2
SET PRESENT PERIOD USAGE AT ALL OUTSIDE Q'S = 0
BEGINIT
A3
SRWGC
DETERMINE WEIGHTED GEOM CENTERS
A4
SET Q & PP INDICATORS = 00
K2
CSQWASZO
A5
SRAOEPP
DETERMINE ALLOWANCE ON Q(4) PP
008 A2
B2
LOAD REG4 WITH START QUARRY CHAIN
IWACSQ
B4
HAS Q(4) BEEN ZONED OUT?
YES
NO
CSQWASDP
B5
SET ALLOWANCE ON Q(4) PP = 0
008 A2
ZNOUTDLP
C2
IS CONTENTS OF REG4 NEG? (ARE WE DONE?)
YES
009 A2
NO
C4
IS LIFE OF Q(4) 0? (HAS Q(4) BEEN DEPLETED?)
YES
NO
H2
D5
ARETMQ
D5
LOAD REG9 WITH START QUARRY CHAIN
D2
SET PRESENT YEARLY USAGE Q(4) =0
NDWSPM
E2
IS Q(4) A S&G QUARRY?
NO
YES
QWASZO
E3
IS Q(4) A PROCESSING PLANT?
YES
NO
DETALOW
E4
SRAOEPP
DETERMINE ALLOWANCE ON Q(4) PP
LFAQ
E5
IS CONTENTS OF REG9 NEG? (ARE WE DONE?)
YES
005 A3
NO
F2
HAS Q(4) BEEN ZONED OUT?
YES
NO
SETALZ
F3
SET ALLOWANCE ON EXISTING PROC PLT = 0
D5
A
F5
YES
IS Q(9) THE SAME QUARRY AS Q(4)?
NO
G2
IS LIFE OF Q(4) 0? (HAS Q(4) BEEN DEPLETED?)
YES
NO
QWASDP
G3
SET Q INDICATOR TO 0. IT CAN NOT BE MINED
UPDTPTR9
G4
LOAD REG9 WITH ADDR NEXT QUARRY
A
G5
NO
IS Q(9) OWNED BY SAME OWNER AS Q(4)?
YES
004 H3
UPDTR4
H2
LOAD ADDR OF NEXT QUARRY INTO REG4
A
H2
004 H2
ZONOUTQ4
H3
LOAD ADDR OF NEXT Q IN CHAIN INTO REG5
H5
YES
HAS Q(9) BEEN ZONED OUT?
NO
J3
SRDQ 018A3
DELETE Q(4) FROM Q CHAIN
J5
IS REMAINING LIFE OF Q(9) GREATER THAN 1 YEAR?
NO
YES
006 A2
K2
LOAD ADDR Q(5) INTO REG4
K2
K3
PRINT MESSAGES AND NOTE
A4

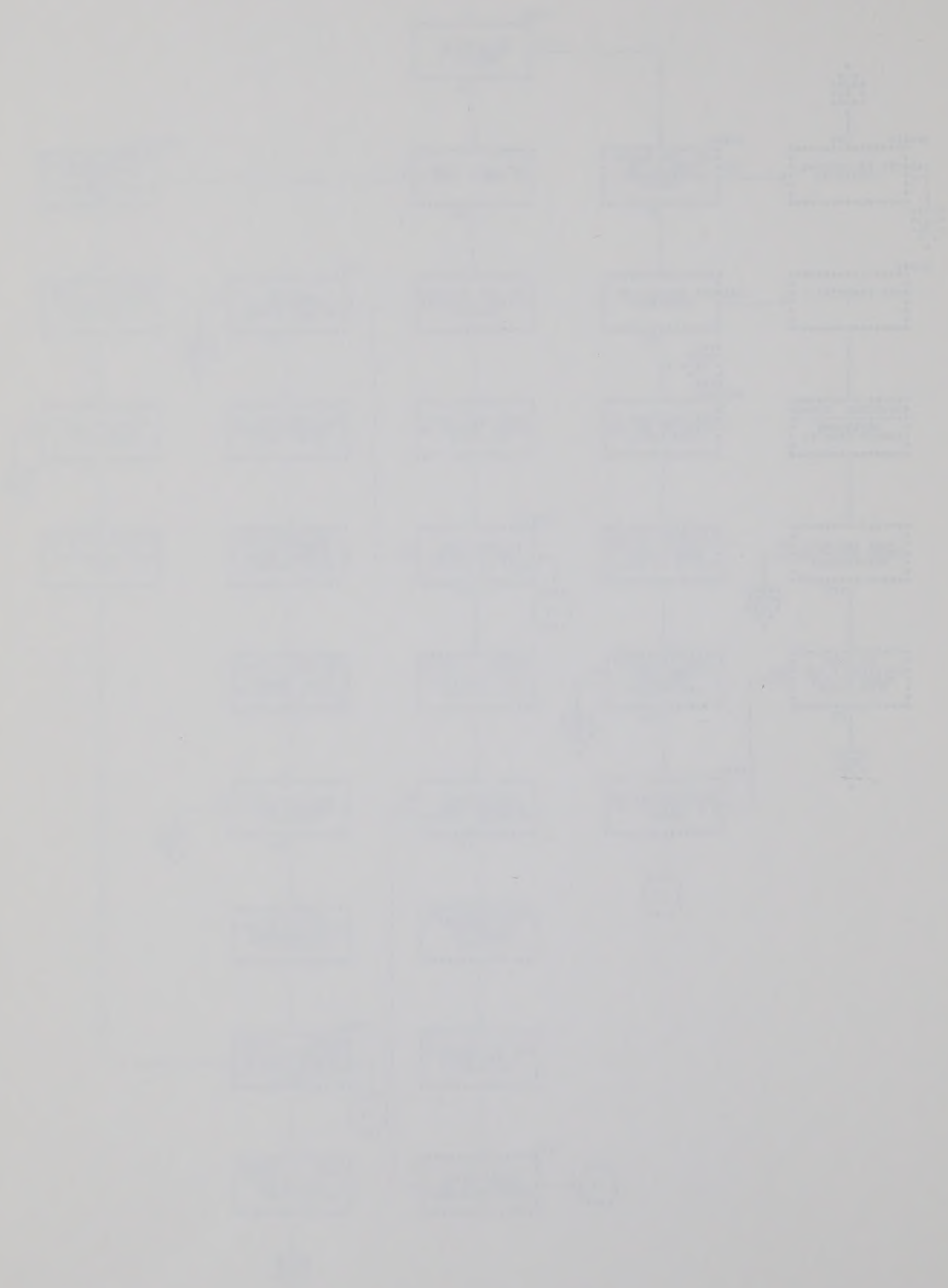

005 A3
OHNOQ
A3
DOES OWNER WISH TO SELF PRESERVE HIS OPERATION?
NO
004 H3
YES
B3
WAS Q(4) A PROCESSING PLANT?
NO
Q4NPP
B4
SET STRATEGY BIT PATTERN = 00000001
YES
Q4PCNC
C2
SET STRATEGY BIT PATTERN = 00000001
C3
CAN PROCESSING CONTINUE (CHECK ZONING LAW) ?
NO
YES
C4
SRPQCOST 014A3
DETERMINE LOWEST COST STRATEGY
D2
SRPQCOST 014A3
DETERMINE LOWEST COST STRATEGY
D3
SET STRATEGY BIT PATTERN = 00000011
WANPTF
D4
WAS A NON PROCESSING TYPE PQ FOUND? (IS NPTPQF=1?)
NO
A
D4
YES
WAPTF
D5
WAS A PROCESSING TYPE PQ FOUND? (IS PTPQF=1?)
NO
YES
F2
004 H3
E2
WERE ANY PROCESSING TYPE PQ'S FOUND? (IS PTPQF=1?)
NO
D4
YES
E3
SRPQCOST 014A3
DETERMINE LOWEST COST STRATEGY
E4
ESTABLISH IT AS A NON PROCESSING TYPE QUARRY
EQWPP
F2
F2
ESTABLISH LOWEST COST PQ AS A Q WITH A PP
F3
WERE ANY PROCESSING TYPE PQ'S FOUND? (IS PTPQF=1) ?
NO
YES
F4
SRDPQ 018A5
DELETE IT FROM PQ CHAIN
G2
SRDPQ 018A5
DELETE IT FROM PQ CHAIN
G3
IS COST BUILDING A PP AT NEW SITE < USING Q(4) AS AN INTER PT?
YES
NO
G4
SRAQ 016A3
ADD IT TO QUARRY CHAIN
004 H3
005 H3
EQWWUIP
H2
SRAQ 016A3
ADD IT TO QUARRY CHAIN
H3
ESTABLISH QUARRY AS A Q USING Q(4) AS AN INTER PT
004 H3
005 J4
PRINTIPM
J3
SRAQ 016A3
ADD IT TO QUARRY CHAIN
J4
UPDATE MATERIAL WASTED
K3
SRDPQ 018A5
DELETE IT FROM PQ CHAIN
K4
PRINT INTER PT MESSAGES
004 H2

MAIN CONT'D
OWNER HAS ANOTHER QUARRY
PAGE 6

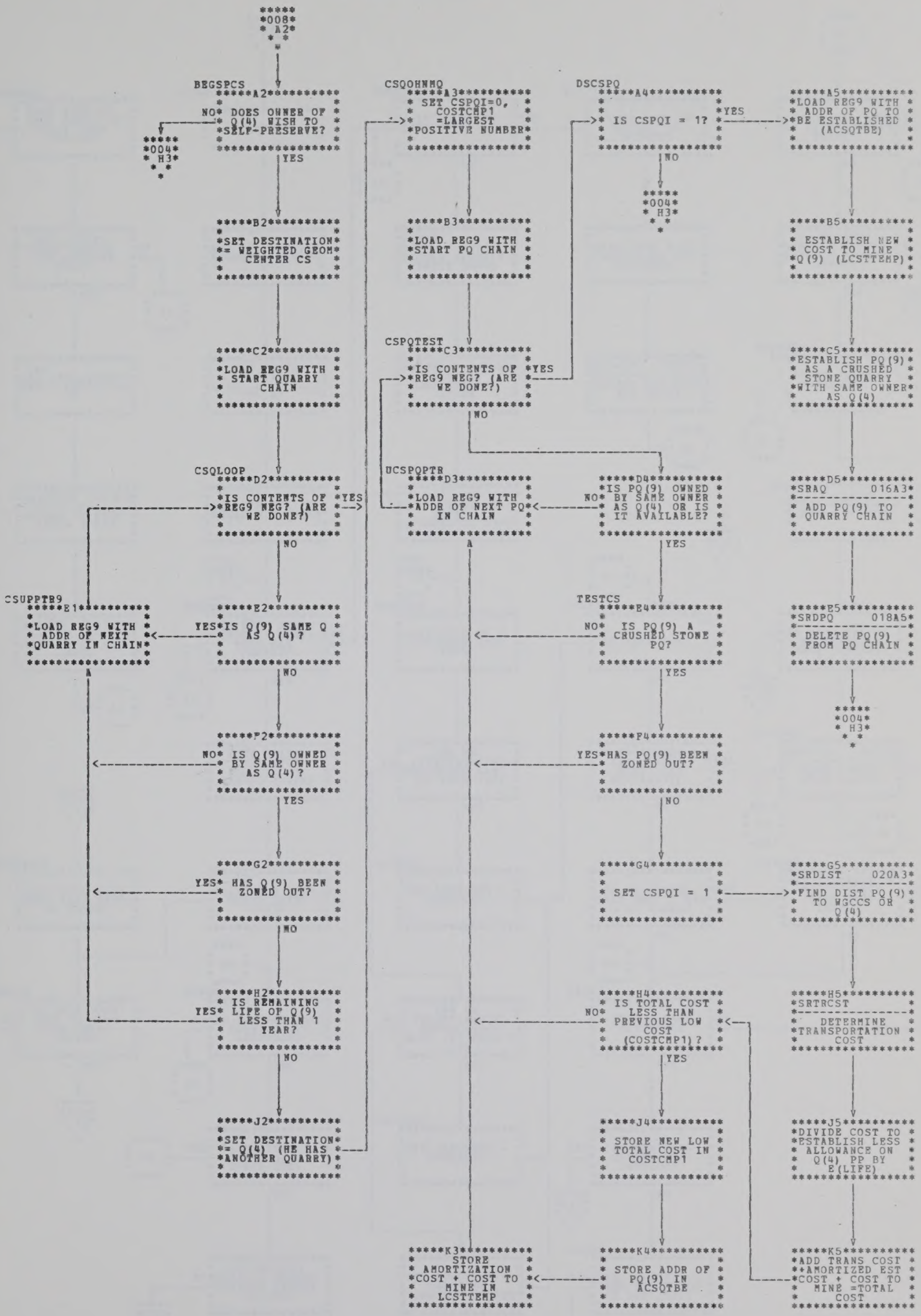

006 A2
OHAQ
A2
SET: IPCOUNT=0, UIPCOUNT=0, IPCHAIN=-1, UIPCHAIN=-1
B2
LOAD REG7 WITH START IPCHAIN, AND REG8 WITH START UIPCHAIN
C1
IS ADDR NEGATIVE? (ARE WE DONE WITH ALL Q'S?)
YES
NO
OHAQLP
C2
IS Q(9) SAME Q AS Q(4)?
NO
YES
UPQPTR9
D1
LOAD REG9 WITH ADDR NEXT Q IN CHAIN
D2
IS Q(9) A S&G QUARRY?
NO
YES
E2
IS Q(9) OWNED BY SAME OWNER AS Q(4)?
NO
YES
UPIPC
E3
SET IPCOUNT = IPCOUNT + 1
F1
CHAINS ARE SET UP. ALTERNATIVES MUST BE INVESTIGATED
007 A3
F2
IS Q(9) AN INTER POINT AND CAN PROCESSING CONTINUE?
YES
NO
F3
IS IPCOUNT > 10?
YES
NO
DQUIP
G2
DOES Q(9) USE AN INTER POINT?
NO
YES
G3
ADD PQ(9) ADDRESS TO IP CHAIN
H2
SET UIPCOUNT = UIPCOUNT +1
THEITCH
H3
PRINT ERROR MESSAGE
J2
IS UIPCOUNT > 10?
YES
NO
J3
ABNORMAL END OF JOB
K2
ADD PQ(9) ADDRESS TO UIP CHAIN
006 A4
Q4IPPCNC
A4
SET FLT PT REG6 = LARG POSITIVE NUMBER
B4
SET: SUMAMT=0, ASDUIP=-1
C4
LOAD REG9 WITH FIRST ADDR IN UIP CHAIN
PCNCLP
D4
IS REG9 NEG? (ARE WE DONE?)
YES
NO
E4
SRDIST 020A3
FIND DISTANCE Q(9) TO WGCPSG
F4
IS DISTANCE SHORTER THAN PREVIOUS SHORT?
NO
YES
G4
STORE ADDR OF QUARRY IN REG9 IN ASDUIP
H4
STORE DISTANCE IN FLT PT REG6
ARL
J4
ADD REMAINING LIFE TO SUMAMT
K4
LOAD REG9 WITH NEXT Q IN UIP CHAIN
007 D2
WEREAF
D5
IS ADDR ASDUIP NEG? (WERE ANY FOUND?
NO
YES
E5
SUBTRACT ALLOWANCE ON PP Q(4) FROM COST NEW PP
F5
DIVIDE BY SUM WEIGHTS (SUMAMT) = NEW AMORT COST
G5
SET Q(9) TO AN INTERMEDIATE POINT
H5
SET NEW AMORTIZATION COST
004 H3

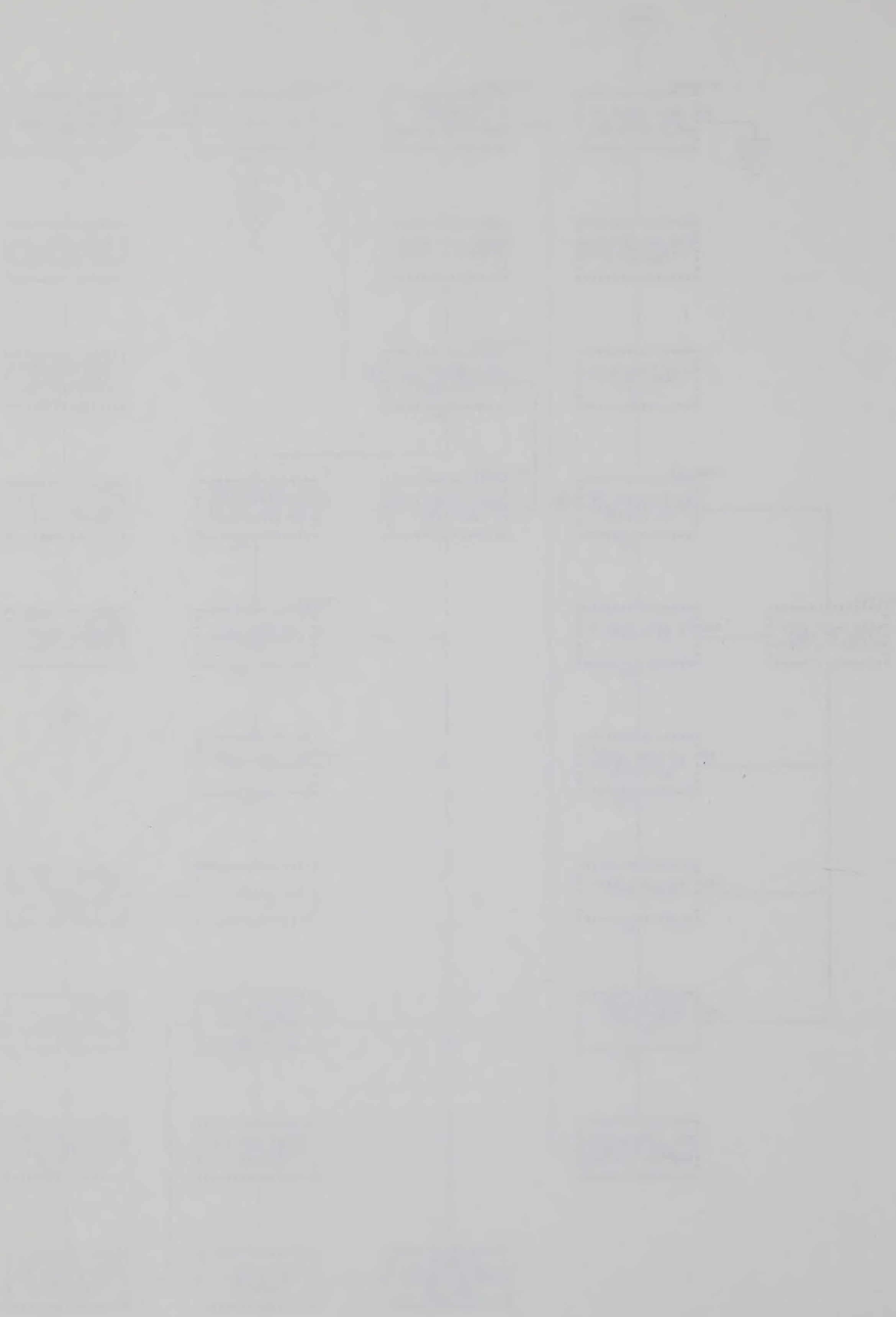

007 A3
OHAQS
A3 WAS Q(4) A PROCESSING PLANT?
YES
NO
006 A4
Q4UAIP
B1 CAN PROCESSING CONTINUE?
YES
NO
005 J4
Q4WPP
B2 WAS Q(4) BEING USED AS AN INTERMEDIATE POINT
YES
NO
B3 WAS Q(4) USING AN INTER POINT?
NO
YES
Q4NPPNIP
B5 SET STRATEGY =4 (FIND LOWEST COST NON-PROCESSING PQ)
PCANC
C1 SET STRATEGY = 7
C2 CAN PROCESSING CONTINUE?
YES
NO
007 D2
C3 SET FLT PT REG4 = LARG POSITIVE NUMBER
CIPD
C4 WERE ANY INTERMEDIATE POINTS FOUND?
NO
YES
004 H3
C5 SRPQCOST 014A3 FIND LOWEST COST PQ
D1 SRPQCOST 014A3 DETERMINE LOWEST COST PQ
Q4PCNCO
D2 SET STRATEGY =5 (=WITH PP AT NEW SITE ONLY)
D3 LOAD REG9 WITH FIRST QUARRY IN IP CHAIN
D4 SET STRATEGY =2 (INTERMEDIATE POINT ONLY)
D5 WERE ANY PQ'S FOUND? (IS NPTPQF=1?)
NO
YES
004 H3
E1 WERE ANY PQ'S FOUND REQUIRING PROCESSING?
NO
YES
004 H3
E2 SRPQCOST 014A3 FIND LOWEST COST Q TO Q(4)
SDIPLP
E3 IS ADDR NEG? (ARE WE DONE WITH IP CHAIN?)
YES
NO
E3
E4 SET QUARRY IN QUESTION = CLOSEST INTER PT TO WGCPSG
E5 ESTABLISH PQ AS A NON-PROCESSING PQ
F1 IS COST BUILDING A NEW PLANT AT THE SITE LOWER?
YES
NO
005 H3
F2 WERE ANY PQ'S FOUND THAT REQUIRE PROCESSING?
NO
YES
004 H3
F3 SRDIST 020A3 FIND DISTANCE Q(9) TO Q(4)
F4 SRPQCOST 014A3 FIND LOWEST COST Q USING AN IP
EWPP
G2 ESTABLISH PQ AS A Q WITH PP AT SITE
J4
G3 IS DISTANCE SHORTER THAN PREVIOUS SHORT?
NO
YES
G4 WERE ANY PQ'S FOUND? (IS PTPQF=1) ?
NO
YES
004 H3
H3 STORE ADDR Q(9) IN CLOSEST INTER PT (CLOSIP)
H4 ESTABLISH LOWEST COST PQ TO SHORTEST DISTANCE IP
DPQAQ
J3 SET FLT PT REG4 = NEW SHORT DISTANCE
J4 SRDPQ 018A5 DELETE LOWEST COST PQ FROM PQ CHAIN
J4
CNIP
K3 LOAD NEXT QUARRY IN IP CHAIN INTO REG9
E3
K4 SRAQ 016A3 ADD IT TO QUARRY CHAIN
004 H3

[illegible]

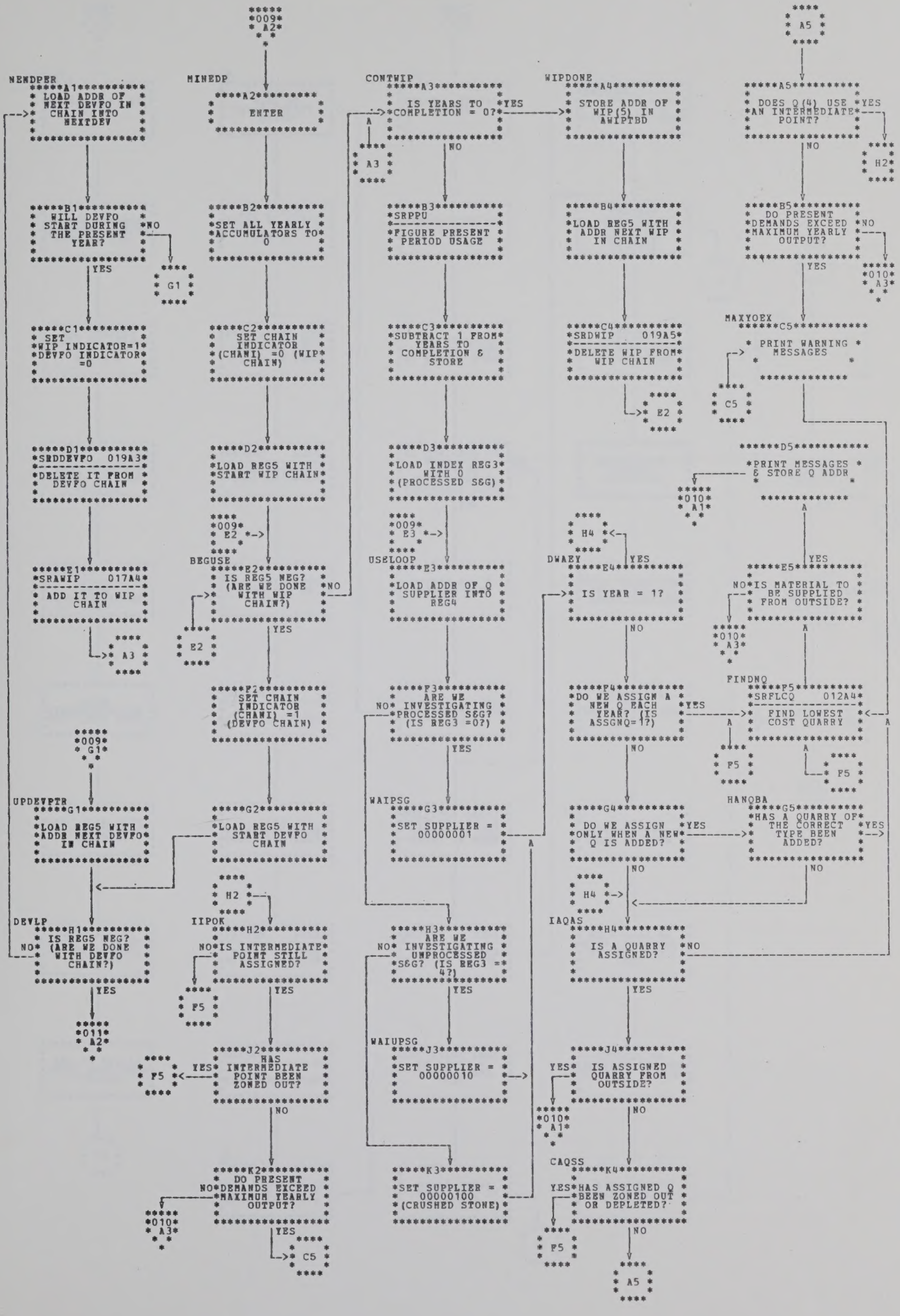


MAIN CONT'D
CRUSHED STONE SELF-PRESERVATION
PAGE 8

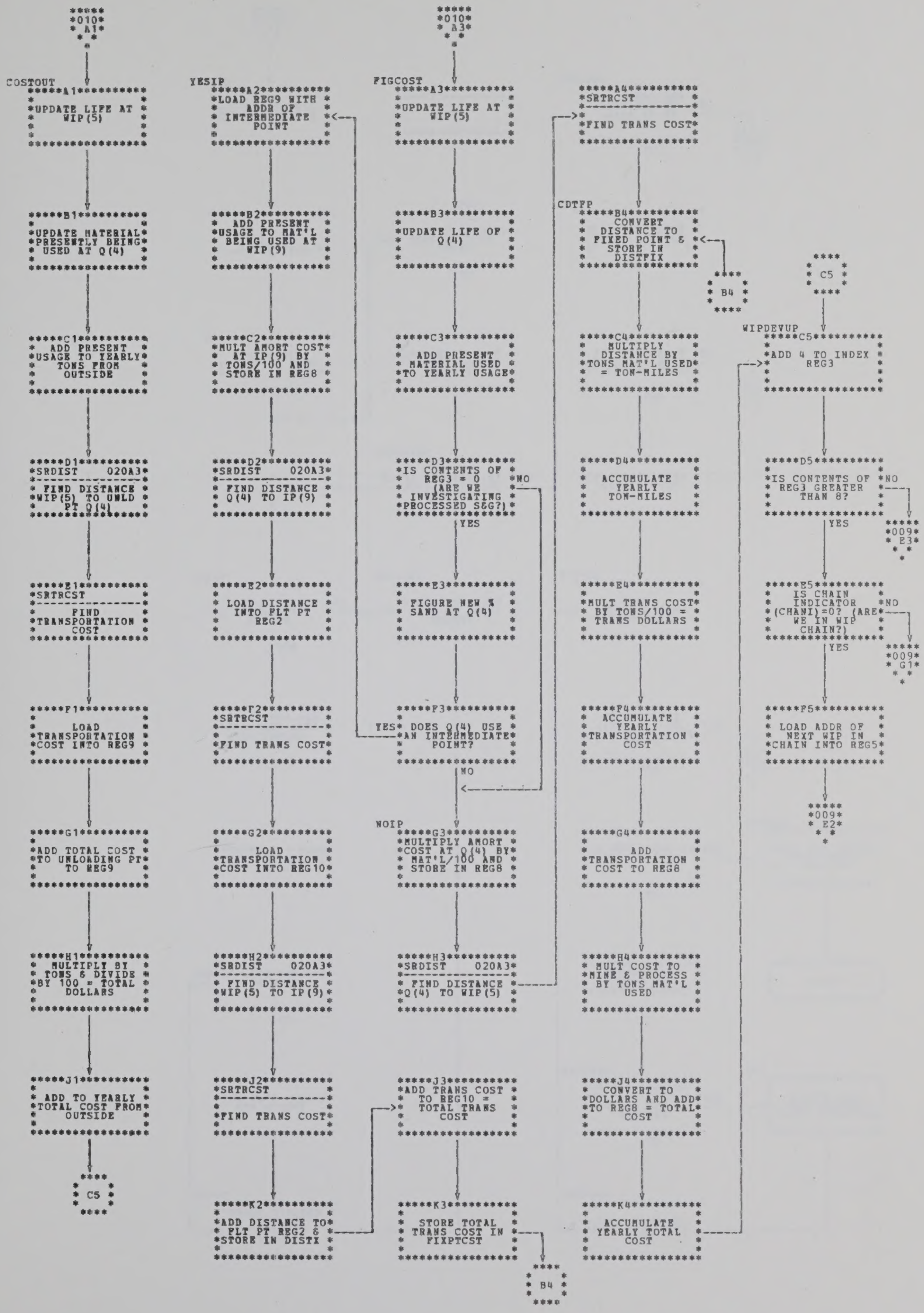

008 A2
BEGSPCS
A2 DOES OWNER OF Q(4) WISH TO SELF-PRESERVE?
NO
004 H3
YES
B2 SET DESTINATION = WEIGHTED GEOM CENTER CS
C2 LOAD REG9 WITH START QUARRY CHAIN
CSQLOOP
D2 IS CONTENTS OF REG9 NEG? (ARE WE DONE?)
YES
NO
CSUPPTR9
E1 LOAD REG9 WITH ADDR OF NEXT QUARRY IN CHAIN
E2 IS Q(9) SAME Q AS Q(4)?
YES
NO
F2 IS Q(9) OWNED BY SAME OWNER AS Q(4)?
NO
YES
G2 HAS Q(9) BEEN ZONED OUT?
YES
NO
H2 IS REMAINING LIFE OF Q(9) LESS THAN 1 YEAR?
YES
NO
J2 SET DESTINATION = Q(4) (HE HAS ANOTHER QUARRY)
CSQOHNMQ
A3 SET CSPQI=0, COSTCMP1 =LARGEST POSITIVE NUMBER
B3 LOAD REG9 WITH START PQ CHAIN
CSPQTEST
C3 IS CONTENTS OF REG9 NEG? (ARE WE DONE?)
YES
NO
UCSPQPTR
D3 LOAD REG9 WITH ADDR OF NEXT PQ IN CHAIN
A
K3 STORE AMORTIZATION COST + COST TO MINE IN LCSTTEMP
DSCSPQ
A4 IS CSPQI = 1?
YES
NO
004 H3
D4 IS PQ(9) OWNED BY SAME OWNER AS Q(4) OR IS IT AVAILABLE?
NO
YES
TESTCS
E4 IS PQ(9) A CRUSHED STONE PQ?
NO
YES
F4 HAS PQ(9) BEEN ZONED OUT?
YES
NO
G4 SET CSPQI = 1
H4 IS TOTAL COST LESS THAN PREVIOUS LOW COST (COSTCMP1)?
NO
YES
J4 STORE NEW LOW TOTAL COST IN COSTCMP1
K4 STORE ADDR OF PQ(9) IN ACSQTBE
A5 LOAD REG9 WITH ADDR OF PQ TO BE ESTABLISHED (ACSQTBE)
B5 ESTABLISH NEW COST TO MINE Q(9) (LCSTTEMP)
C5 ESTABLISH PQ(9) AS A CRUSHED STONE QUARRY WITH SAME OWNER AS Q(4)
D5 SRAQ 016A3
ADD PQ(9) TO QUARRY CHAIN
E5 SRDPQ 018A5
DELETE PQ(9) FROM PQ CHAIN
004 H3
G5 SRDIST 020A3
FIND DIST PQ(9) TO WGCCS OR Q(4)
H5 SRTRCST
DETERMINE TRANSPORTATION COST
J5 DIVIDE COST TO ESTABLISH LESS ALLOWANCE ON Q(4) PP BY E(LIFE)
K5 ADD TRANS COST +AMORTIZED EST COST + COST TO MINE =TOTAL COST



DATA PROCESSING SECTION

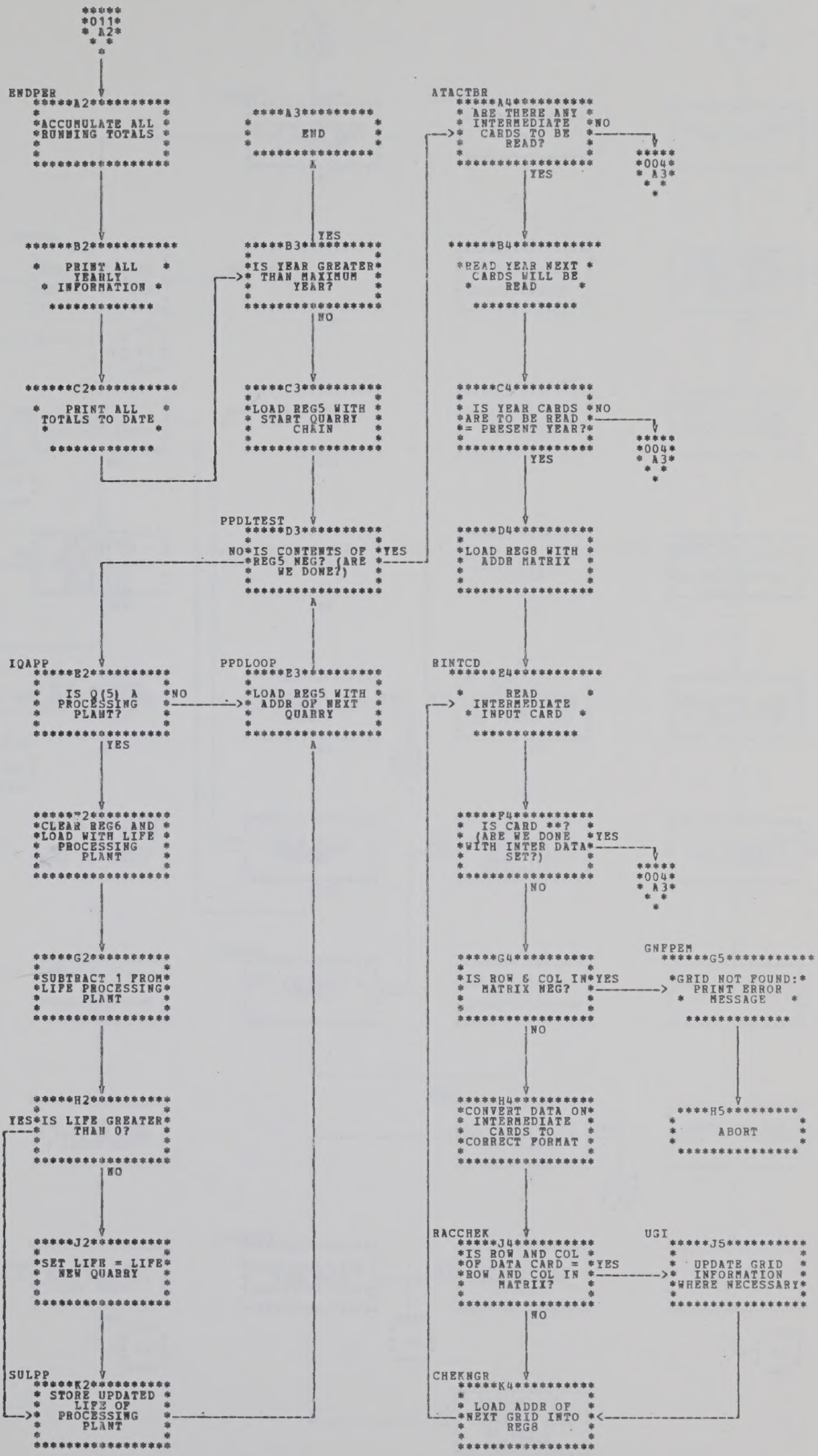

009 A2
A5
NEWDPER
A1
LOAD ADDR OF NEXT DEVFO IN CHAIN INTO NEXTDEV
MINEDP
A2
ENTER
CONTWIP
A3
IS YEARS TO COMPLETION = 0?
YES
A3
NO
WIPDONE
A4
STORE ADDR OF WIP(5) IN AWIPTBD
A5
DOES Q(4) USE AN INTERMEDIATE POINT?
YES
H2
NO
B1
WILL DEVFO START DURING THE PRESENT YEAR?
NO
G1
YES
B2
SET ALL YEARLY ACCUMULATORS TO 0
B3
SRPPU
FIGURE PRESENT PERIOD USAGE
B4
LOAD REG5 WITH ADDR NEXT WIP IN CHAIN
B5
DO PRESENT DEMANDS EXCEED MAXIMUM YEARLY OUTPUT?
NO
010 A3
YES
C1
SET WIP INDICATOR=1 DEVFO INDICATOR =0
C2
SET CHAIN INDICATOR (CHANI) =0 (WIP CHAIN)
C3
SUBTRACT 1 FROM YEARS TO COMPLETION & STORE
C4
SRDWIP 019A5
DELETE WIP FROM WIP CHAIN
E2
MAXYOEX
C5
PRINT WARNING MESSAGES
C5
D1
SRDDEVFO 019A3
DELETE IT FROM DEVFO CHAIN
D2
LOAD REG5 WITH START WIP CHAIN
D3
LOAD INDEX REG3 WITH 0 (PROCESSED S&G)
D5
PRINT MESSAGES & STORE Q ADDR
010 A1
009 E2
009 E3
H4
BEGUSE
E2
IS REG5 NEG? (ARE WE DONE WITH WIP CHAIN?)
NO
E2
YES
USELOOP
E3
LOAD ADDR OF Q SUPPLIER INTO REG4
DWAEY
E4
IS YEAR = 1?
YES
NO
E5
IS MATERIAL TO BE SUPPLIED FROM OUTSIDE?
NO
010 A3
YES
E1
SRAWIP 017A4
ADD IT TO WIP CHAIN
A3
F2
SET CHAIN INDICATOR (CHANI) =1 (DEVFO CHAIN)
F3
ARE WE INVESTIGATING PROCESSED S&G? (IS REG3 =0?)
NO
YES
F4
DO WE ASSIGN A NEW Q EACH YEAR? (IS ASSGNQ=1?)
YES
NO
F5
FINDNQ
F5
SRFLCQ 012A4
FIND LOWEST COST QUARRY
F5
009 G1
UPDEVPTR
G1
LOAD REG5 WITH ADDR NEXT DEVFO IN CHAIN
G2
LOAD REG5 WITH START DEVFO CHAIN
WAIPSG
G3
SET SUPPLIER = 00000001
G4
DO WE ASSIGN ONLY WHEN A NEW Q IS ADDED?
YES
NO
HANQBA
G5
HAS A QUARRY OF THE CORRECT TYPE BEEN ADDED?
YES
NO
H2
H4
DEVLP
H1
IS REG5 NEG? (ARE WE DONE WITH DEVFO CHAIN?)
NO
YES
011 A2
IIPOK
H2
IS INTERMEDIATE POINT STILL ASSIGNED?
NO
F5
YES
H3
ARE WE INVESTIGATING UNPROCESSED S&G? (IS REG3 = 4?)
NO
YES
IAQAS
H4
IS A QUARRY ASSIGNED?
NO
YES
F5
J2
HAS INTERMEDIATE POINT BEEN ZONED OUT?
YES
NO
WAIUPSG
J3
SET SUPPLIER = 00000010
J4
IS ASSIGNED QUARRY FROM OUTSIDE?
YES
010 A1
NO
CAQSS
K2
DO PRESENT DEMANDS EXCEED MAXIMUM YEARLY OUTPUT?
NO
010 A3
YES
C5
K3
SET SUPPLIER = 00000100 (CRUSHED STONE)
K4
HAS ASSIGNED Q BEEN ZONED OUT OR DEPLETED?
YES
F5
NO
A5

DATA PROCESSING SECTION CONT'D

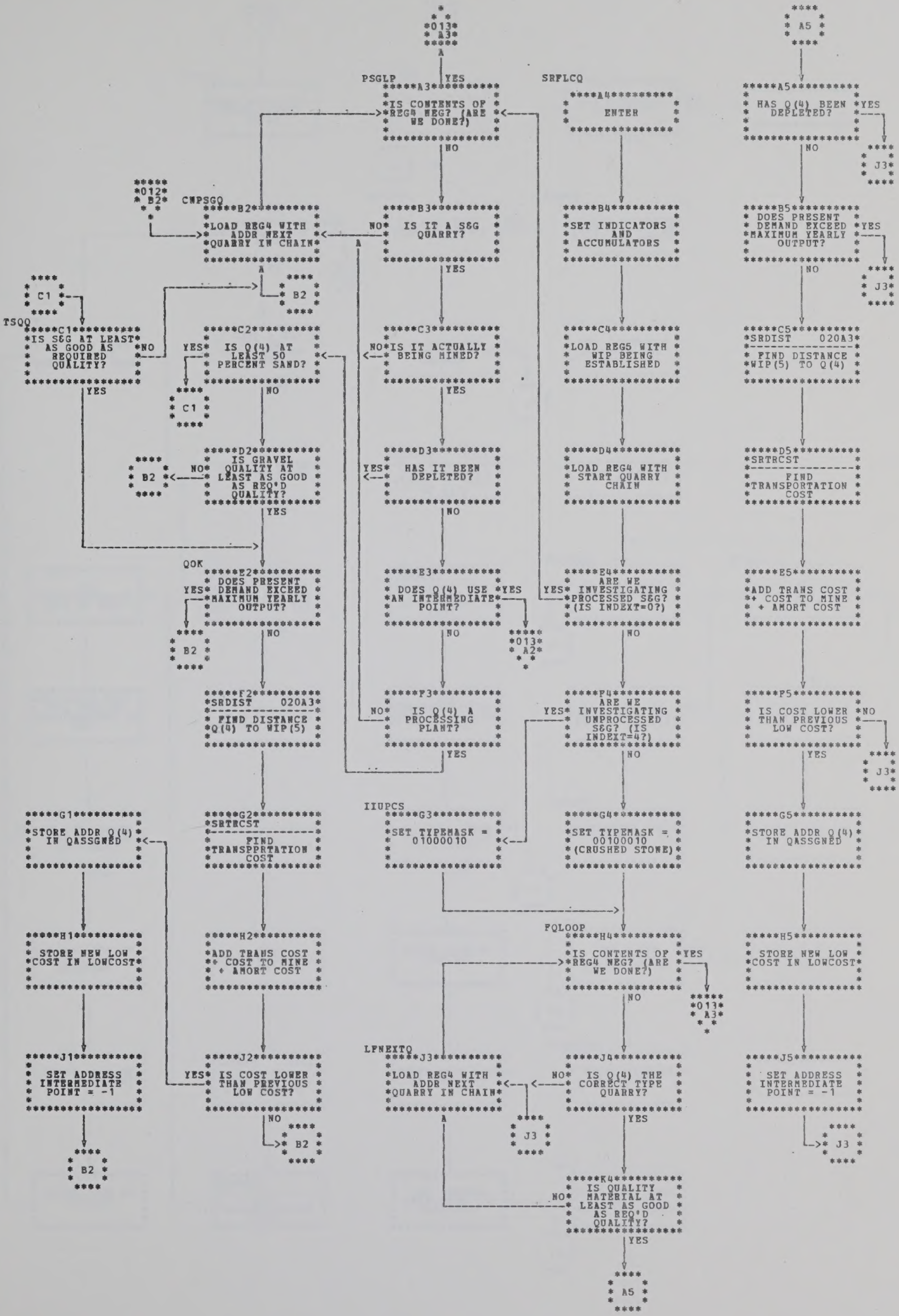

010 A1
010 A3
COSTOUT
A1 UPDATE LIFE AT WIP(5)
B1 UPDATE MATERIAL PRESENTLY BEING USED AT Q(4)
C1 ADD PRESENT USAGE TO YEARLY TONS FROM OUTSIDE
D1 SRDIST 020A3 FIND DISTANCE WIP(5) TO UNLD PT Q(4)
E1 SRTRCST FIND TRANSPORTATION COST
F1 LOAD TRANSPORTATION COST INTO REG9
G1 ADD TOTAL COST TO UNLOADING PT TO REG9
H1 MULTIPLY BY TONS & DIVIDE BY 100 = TOTAL DOLLARS
J1 ADD TO YEARLY TOTAL COST FROM OUTSIDE
C5
YESIP
A2 LOAD REG9 WITH ADDR OF INTERMEDIATE POINT
B2 ADD PRESENT USAGE TO MAT'L BEING USED AT WIP(9)
C2 MULT AMORT COST AT IP(9) BY TONS/100 AND STORE IN REG8
D2 SRDIST 020A3 FIND DISTANCE Q(4) TO IP(9)
E2 LOAD DISTANCE INTO FLT PT REG2
F2 SRTRCST FIND TRANS COST
G2 LOAD TRANSPORTATION COST INTO REG10
H2 SRDIST 020A3 FIND DISTANCE WIP(5) TO IP(9)
J2 SRTRCST FIND TRANS COST
K2 ADD DISTANCE TO FLT PT REG2 & STORE IN DISTX
FIGCOST
A3 UPDATE LIFE AT WIP(5)
B3 UPDATE LIFE OF Q(4)
C3 ADD PRESENT MATERIAL USED TO YEARLY USAGE
D3 IS CONTENTS OF REG3 = 0 (ARE WE INVESTIGATING PROCESSED S&G?)
NO
YES
E3 FIGURE NEW % SAND AT Q(4)
F3 DOES Q(4) USE AN INTERMEDIATE POINT?
YES
NO
NOIP
G3 MULTIPLY AMORT COST AT Q(4) BY MAT'L/100 AND STORE IN REG8
H3 SRDIST 020A3 FIND DISTANCE Q(4) TO WIP(5)
J3 ADD TRANS COST TO REG10 = TOTAL TRANS COST
K3 STORE TOTAL TRANS COST IN FIXPTCST
B4
A4 SRTRCST FIND TRANS COST
CDTFP
B4 CONVERT DISTANCE TO FIXED POINT & STORE IN DISTFIX
B4
C4 MULTIPLY DISTANCE BY TONS MAT'L USED = TON-MILES
D4 ACCUMULATE YEARLY TON-MILES
E4 MULT TRANS COST BY TONS/100 = TRANS DOLLARS
F4 ACCUMULATE YEARLY TRANSPORTATION COST
G4 ADD TRANSPORTATION COST TO REG8
H4 MULT COST TO MINE & PROCESS BY TONS MAT'L USED
J4 CONVERT TO DOLLARS AND ADD TO REG8 = TOTAL COST
K4 ACCUMULATE YEARLY TOTAL COST
C5
WIPDEVUP
C5 ADD 4 TO INDEX REG3
D5 IS CONTENTS OF REG3 GREATER THAN 8?
NO
009 E3
YES
E5 IS CHAIN INDICATOR (CHANI)=0? (ARE WE IN WIP CHAIN?)
NO
009 G1
YES
F5 LOAD ADDR OF NEXT WIP IN CHAIN INTO REG5
009 E2

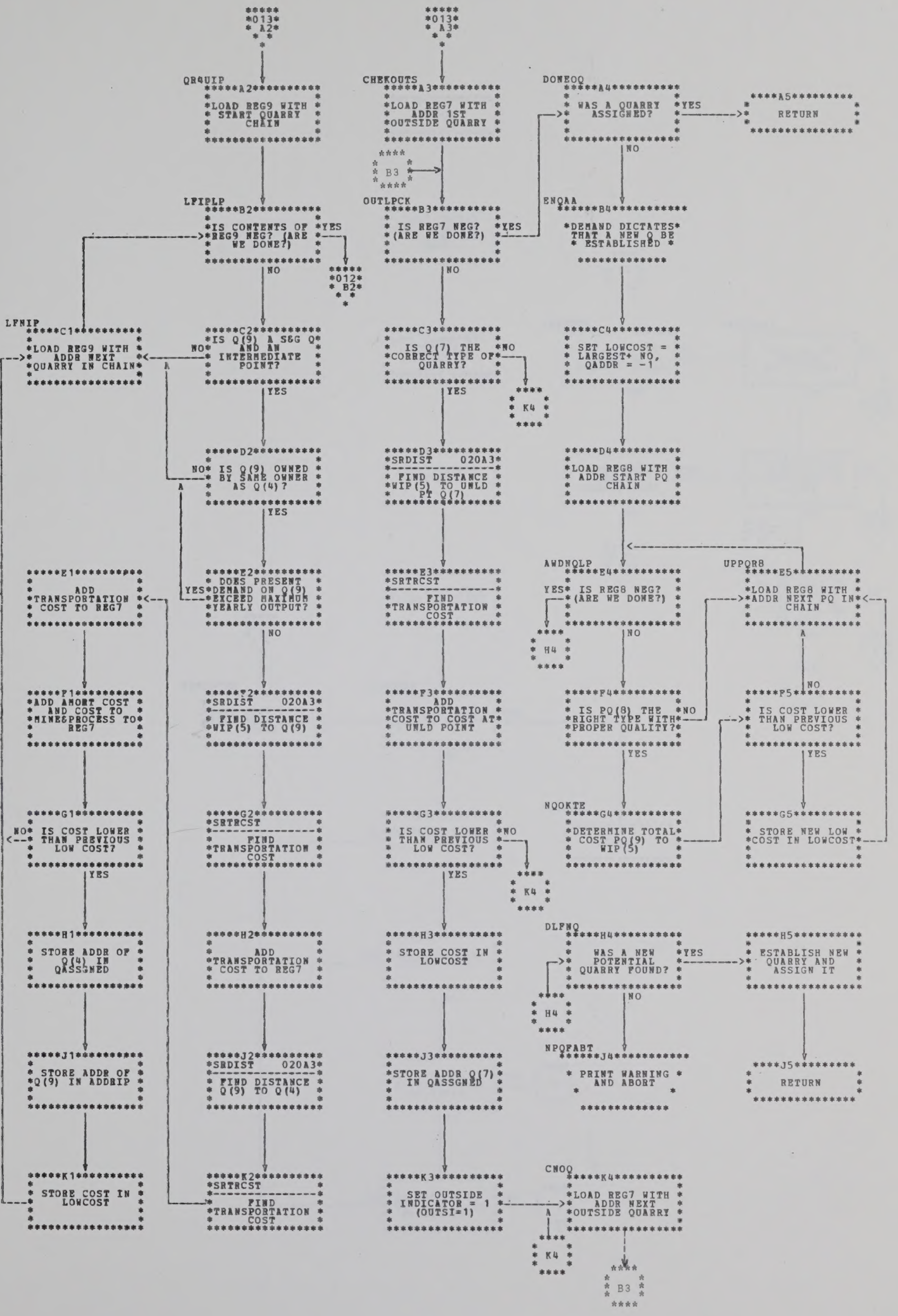
END OF PERIOD ADJUSTMENTS

LAST PAGE MAIN PROGRAM

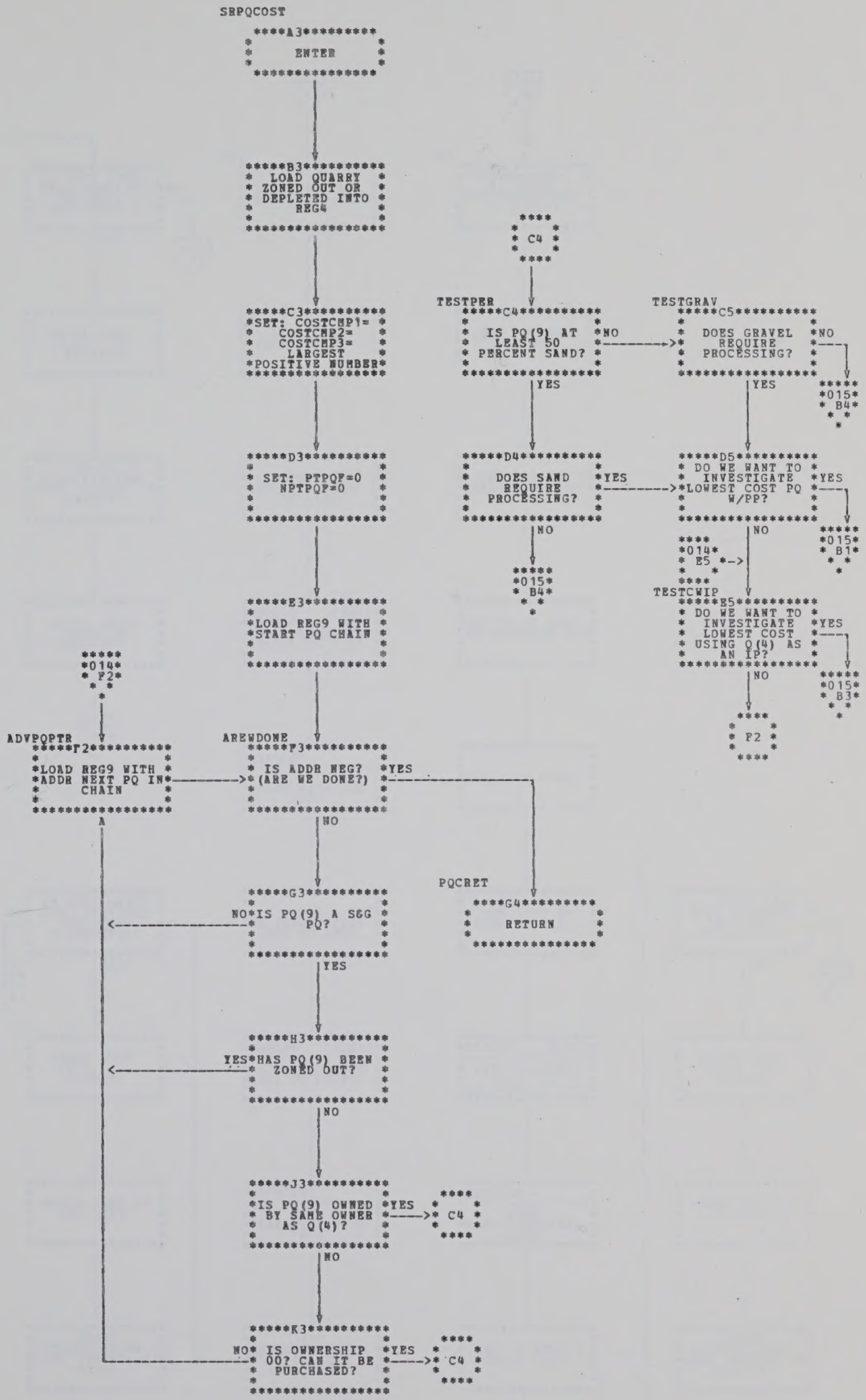

011
A2
ENDPER
A2
ACCUMULATE ALL RUNNING TOTALS
B2
PRINT ALL YEARLY INFORMATION
C2
PRINT ALL TOTALS TO DATE
A3
END
B3
IS YEAR GREATER THAN MAXIMUM YEAR?
YES
NO
C3
LOAD REG5 WITH START QUARRY CHAIN
PPDLTEST
D3
IS CONTENTS OF REG5 NEG? (ARE WE DONE?)
NO
YES
IQAPP
E2
IS Q(5) A PROCESSING PLANT?
NO
YES
PPDLOOP
E3
LOAD REG5 WITH ADDR OF NEXT QUARRY
F2
CLEAR REG6 AND LOAD WITH LIFE PROCESSING PLANT
G2
SUBTRACT 1 FROM LIFE PROCESSING PLANT
H2
IS LIFE GREATER THAN 0?
YES
NO
J2
SET LIFE = LIFE NEW QUARRY
SULPP
K2
STORE UPDATED LIFE OF PROCESSING PLANT
ATACTBR
A4
ARE THERE ANY INTERMEDIATE CARDS TO BE READ?
NO
YES
004
A3
B4
READ YEAR NEXT CARDS WILL BE READ
C4
IS YEAR CARDS ARE TO BE READ = PRESENT YEAR?
NO
YES
004
A3
D4
LOAD REG8 WITH ADDR MATRIX
RINTCD
E4
READ INTERMEDIATE INPUT CARD
F4
IS CARD **? (ARE WE DONE WITH INTER DATA SET?)
YES
NO
004
A3
G4
IS ROW & COL IN MATRIX NEG?
YES
NO
GNFPEM
G5
GRID NOT FOUND: PRINT ERROR MESSAGE
H4
CONVERT DATA ON INTERMEDIATE CARDS TO CORRECT FORMAT
H5
ABORT
RACCHEK
J4
IS ROW AND COL OF DATA CARD = ROW AND COL IN MATRIX?
YES
NO
UGI
J5
UPDATE GRID INFORMATION WHERE NECESSARY
CHEKNGR
K4
LOAD ADDR OF NEXT GRID INTO REG8

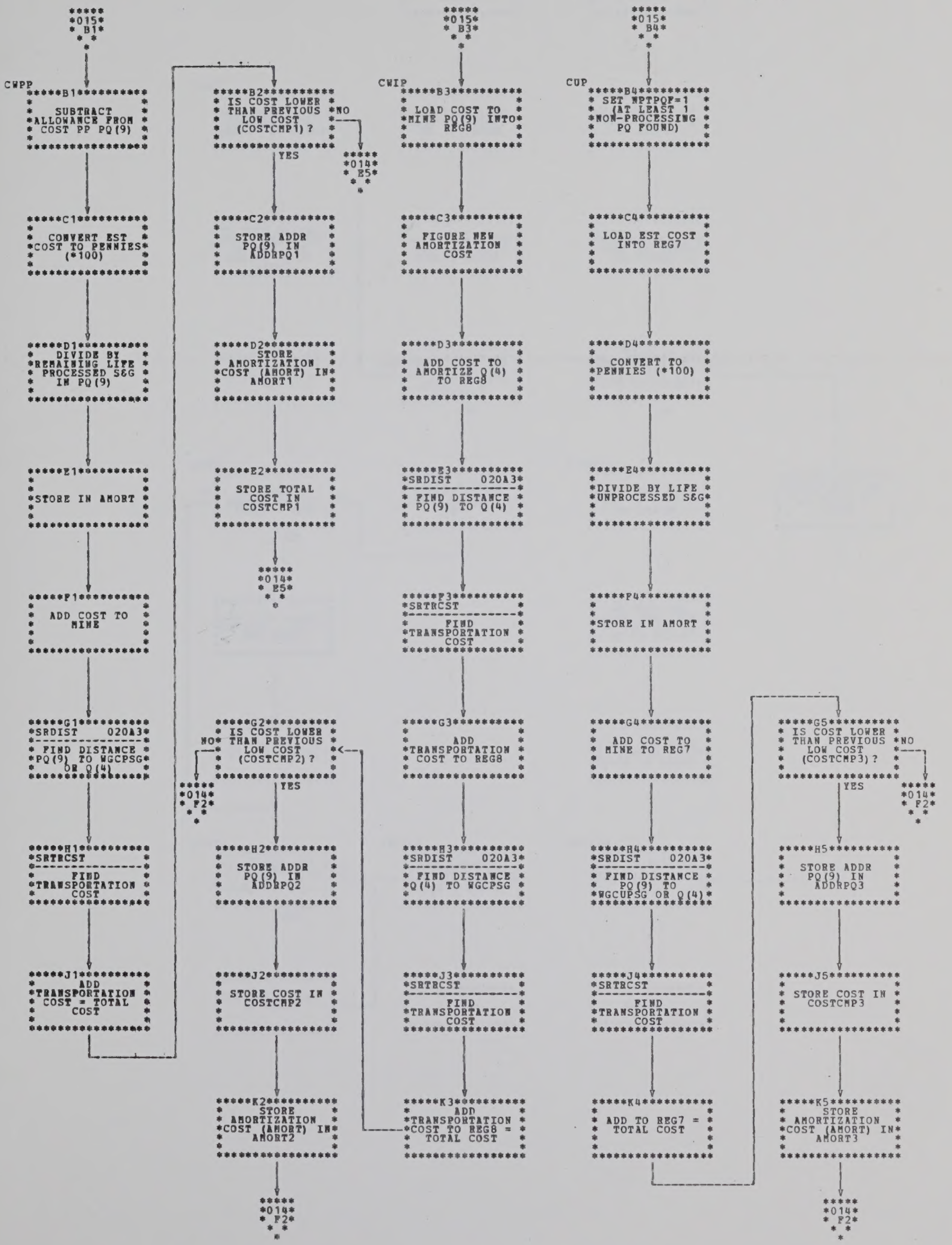
SUBROUTINE FIND LOWEST COST QUARRY
SRFLCQ
(NEW QUARRY ASSIGNMENT MODEL)


013 A3
PSGLP
A3
IS CONTENTS OF REG4 NEG? (ARE WE DONE?)
YES
NO
SRFLCQ
A4
ENTER
A5
A5
HAS Q(4) BEEN DEPLETED?
YES
NO
J3
012 B2
CNPSGQ
B2
LOAD REG4 WITH ADDR NEXT QUARRY IN CHAIN
B3
IS IT A S&G QUARRY?
NO
YES
B4
SET INDICATORS AND ACCUMULATORS
B5
DOES PRESENT DEMAND EXCEED MAXIMUM YEARLY OUTPUT?
YES
NO
J3
C1
B2
TSQQ
C1
IS S&G AT LEAST AS GOOD AS REQUIRED QUALITY?
NO
YES
C2
IS Q(4) AT LEAST 50 PERCENT SAND?
YES
NO
C1
C3
IS IT ACTUALLY BEING MINED?
NO
YES
C4
LOAD REG5 WITH WIP BEING ESTABLISHED
C5
SRDIST 020A3
FIND DISTANCE WIP(5) TO Q(4)
B2
D2
IS GRAVEL QUALITY AT LEAST AS GOOD AS REQ'D QUALITY?
NO
YES
D3
HAS IT BEEN DEPLETED?
YES
NO
D4
LOAD REG4 WITH START QUARRY CHAIN
D5
SRTRCST
FIND TRANSPORTATION COST
QOK
E2
DOES PRESENT DEMAND EXCEED MAXIMUM YEARLY OUTPUT?
YES
NO
B2
E3
DOES Q(4) USE AN INTERMEDIATE POINT?
YES
NO
013 A2
E4
ARE WE INVESTIGATING PROCESSED S&G? (IS INDEXT=0?)
YES
NO
E5
ADD TRANS COST + COST TO MINE + AMORT COST
F2
SRDIST 020A3
FIND DISTANCE Q(4) TO WIP(5)
F3
IS Q(4) A PROCESSING PLANT?
NO
YES
F4
ARE WE INVESTIGATING UNPROCESSED S&G? (IS INDEXT=4?)
YES
NO
F5
IS COST LOWER THAN PREVIOUS LOW COST?
NO
YES
J3
G1
STORE ADDR Q(4) IN QASSGNED
G2
SRTRCST
FIND TRANSPPRTATION COST
IIUPCS
G3
SET TYPEMASK = 01000010
G4
SET TYPEMASK = 00100010 (CRUSHED STONE)
G5
STORE ADDR Q(4) IN QASSGNED
H1
STORE NEW LOW COST IN LOWCOST
H2
ADD TRANS COST + COST TO MINE + AMORT COST
FQLOOP
H4
IS CONTENTS OF REG4 NEG? (ARE WE DONE?)
YES
NO
013 A3
H5
STORE NEW LOW COST IN LOWCOST
J1
SET ADDRESS INTERMEDIATE POINT = -1
B2
J2
IS COST LOWER THAN PREVIOUS LOW COST?
YES
NO
B2
LFNEXTQ
J3
LOAD REG4 WITH ADDR NEXT QUARRY IN CHAIN
J3
J4
IS Q(4) THE CORRECT TYPE QUARRY?
NO
YES
J5
SET ADDRESS INTERMEDIATE POINT = -1
J3
K4
IS QUALITY MATERIAL AT LEAST AS GOOD AS REQ'D QUALITY?
NO
YES
A5

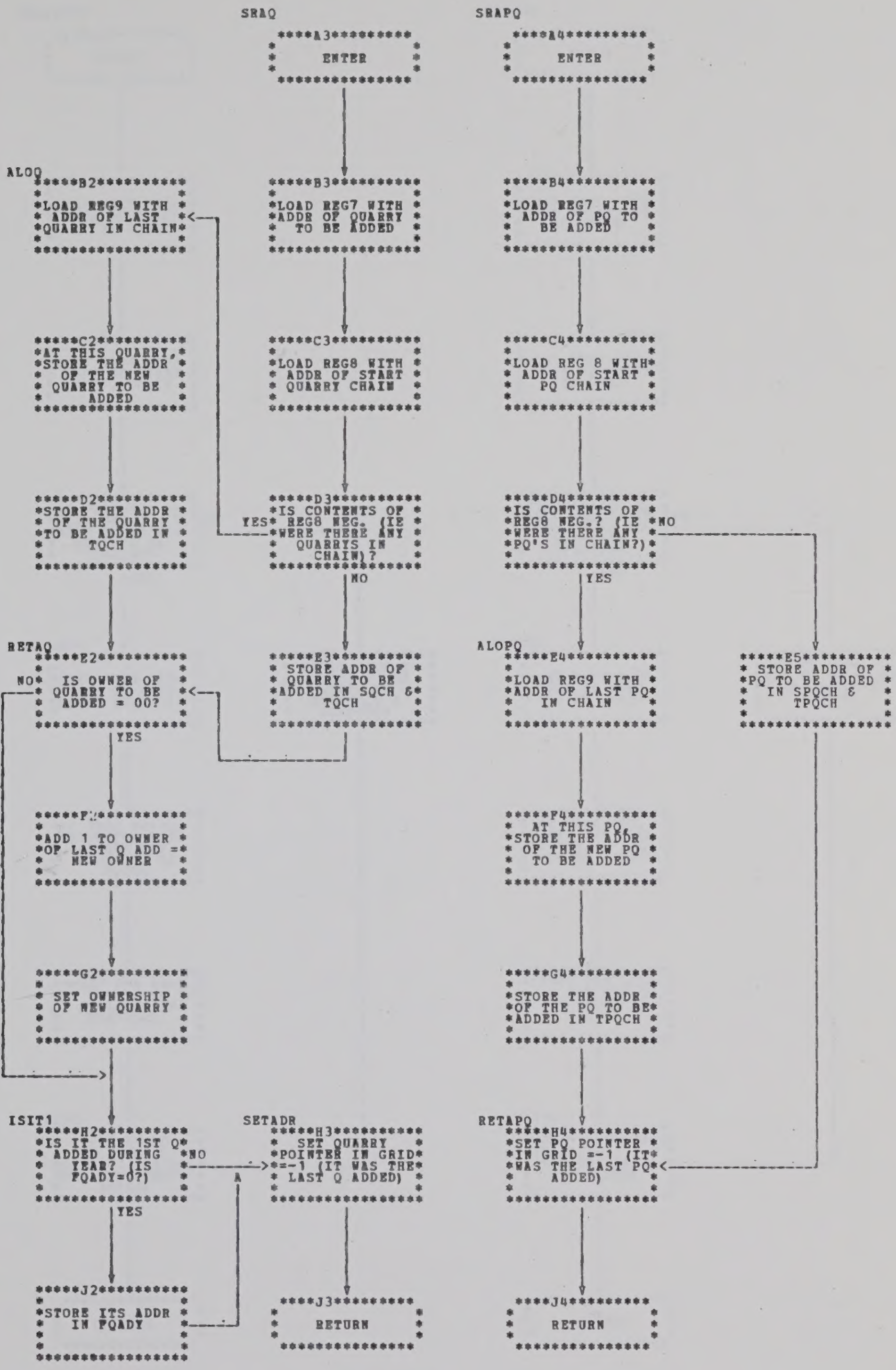

013 A2
013 A3
QR4UIP
A2
LOAD REG9 WITH START QUARRY CHAIN
CHEKOUTS
A3
LOAD REG7 WITH ADDR 1ST OUTSIDE QUARRY
DONEOQ
A4
WAS A QUARRY ASSIGNED?
YES
A5
RETURN
NO
B3
LFIPLP
B2
IS CONTENTS OF REG9 NEG? (ARE WE DONE?)
YES
NO
012 B2
OUTLPCK
B3
IS REG7 NEG? (ARE WE DONE?)
YES
NO
ENQAA
B4
DEMAND DICTATES THAT A NEW Q BE ESTABLISHED
LFNIP
C1
LOAD REG9 WITH ADDR NEXT QUARRY IN CHAIN
C2
IS Q(9) A S&G Q AND AN INTERMEDIATE POINT?
NO
YES
A
C3
IS Q(7) THE CORRECT TYPE OF QUARRY?
NO
YES
K4
C4
SET LOWCOST = LARGEST+ NO, QADDR = -1
D2
IS Q(9) OWNED BY SAME OWNER AS Q(4)?
NO
YES
A
D3
SRDIST 020A3
FIND DISTANCE WIP(5) TO UNLD PT Q(7)
D4
LOAD REG8 WITH ADDR START PQ CHAIN
E1
ADD TRANSPORTATION COST TO REG7
E2
DOES PRESENT DEMAND ON Q(9) EXCEED MAXIMUM YEARLY OUTPUT?
YES
NO
E3
SRTRCST
FIND TRANSPORTATION COST
AWDNQLP
E4
IS REG8 NEG? (ARE WE DONE?)
YES
NO
H4
UPPQR8
E5
LOAD REG8 WITH ADDR NEXT PQ IN CHAIN
A
F1
ADD AMORT COST AND COST TO MINE&PROCESS TO REG7
F2
SRDIST 020A3
FIND DISTANCE WIP(5) TO Q(9)
F3
ADD TRANSPORTATION COST TO COST AT UNLD POINT
F4
IS PQ(8) THE RIGHT TYPE WITH PROPER QUALITY?
NO
YES
F5
IS COST LOWER THAN PREVIOUS LOW COST?
NO
YES
G1
IS COST LOWER THAN PREVIOUS LOW COST?
NO
YES
G2
SRTRCST
FIND TRANSPORTATION COST
G3
IS COST LOWER THAN PREVIOUS LOW COST?
NO
YES
K4
NQOKTE
G4
DETERMINE TOTAL COST PQ(9) TO WIP(5)
G5
STORE NEW LOW COST IN LOWCOST
H1
STORE ADDR OF Q(4) IN QASSGNED
H2
ADD TRANSPORTATION COST TO REG7
H3
STORE COST IN LOWCOST
DLFNQ
H4
WAS A NEW POTENTIAL QUARRY FOUND?
YES
NO
H4
H5
ESTABLISH NEW QUARRY AND ASSIGN IT
J1
STORE ADDR OF Q(9) IN ADDRIP
J2
SRDIST 020A3
FIND DISTANCE Q(9) TO Q(4)
J3
STORE ADDR Q(7) IN QASSGNED
NPQFABT
J4
PRINT WARNING AND ABORT
J5
RETURN
K1
STORE COST IN LOWCOST
K2
SRTRCST
FIND TRANSPORTATION COST
K3
SET OUTSIDE INDICATOR = 1 (OUTSI=1)
CNOQ
K4
LOAD REG7 WITH ADDR NEXT OUTSIDE QUARRY
A
K4
B3

POTENTIAL QUARRY COST INVESTIGATION


SRPQCOST
A3
ENTER
B3
LOAD QUARRY ZONED OUT OR DEPLETED INTO REG4
C3
SET: COSTCMP1= COSTCMP2= COSTCMP3= LARGEST POSITIVE NUMBER
D3
SET: PTPQF=0 NPTPQF=0
E3
LOAD REG9 WITH START PQ CHAIN
014 F2
ADVPQPTR
F2
LOAD REG9 WITH ADDR NEXT PQ IN CHAIN
AREWDONE
F3
IS ADDR NEG? (ARE WE DONE?)
YES
NO
G3
IS PQ(9) A S&G PQ?
NO
YES
H3
HAS PQ(9) BEEN ZONED OUT?
YES
NO
J3
IS PQ(9) OWNED BY SAME OWNER AS Q(4)?
YES
C4
NO
K3
IS OWNERSHIP 00? CAN IT BE PURCHASED?
NO
YES
C4
A
PQCRET
G4
RETURN
C4
TESTPER
C4
IS PQ(9) AT LEAST 50 PERCENT SAND?
NO
YES
D4
DOES SAND REQUIRE PROCESSING?
YES
NO
015 B4
TESTGRAV
C5
DOES GRAVEL REQUIRE PROCESSING?
NO
015 B4
YES
D5
DO WE WANT TO INVESTIGATE LOWEST COST PQ W/PP?
YES
015 B1
NO
014 E5
TESTCWIP
E5
DO WE WANT TO INVESTIGATE LOWEST COST USING Q(4) AS AN IP?
YES
015 B3
NO
F2

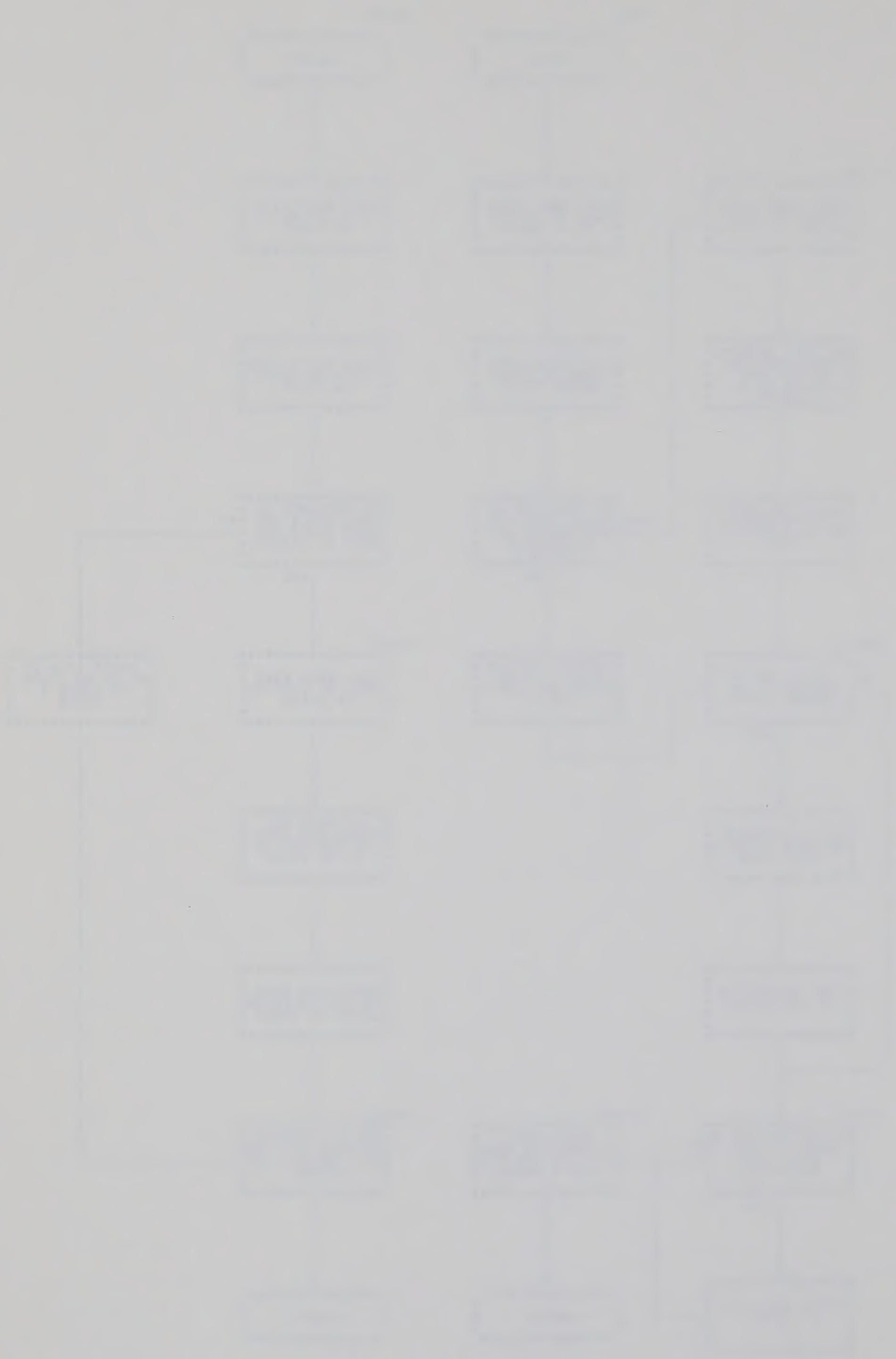

015 B1
CWPP
B1 SUBTRACT ALLOWANCE FROM COST PP PQ(9)
C1 CONVERT EST COST TO PENNIES (*100)
D1 DIVIDE BY REMAINING LIFE PROCESSED S&G IN PQ(9)
E1 STORE IN AMORT
F1 ADD COST TO MINE
G1 SRDIST 020A3 FIND DISTANCE PQ(9) TO WGCPSG OR Q(4)
H1 SRTRCST FIND TRANSPORTATION COST
J1 ADD TRANSPORTATION COST = TOTAL COST
B2 IS COST LOWER THAN PREVIOUS LOW COST (COSTCMP1) ?
NO
014 E5
YES
C2 STORE ADDR PQ(9) IN ADDRPQ1
D2 STORE AMORTIZATION COST (AMORT) IN AMORT1
E2 STORE TOTAL COST IN COSTCMP1
014 E5
G2 IS COST LOWER THAN PREVIOUS LOW COST (COSTCMP2) ?
NO
014 F2
YES
H2 STORE ADDR PQ(9) IN ADDRPQ2
J2 STORE COST IN COSTCMP2
K2 STORE AMORTIZATION COST (AMORT) IN AMORT2
014 F2
015 B3
CWIP
B3 LOAD COST TO MINE PQ(9) INTO REG8
C3 FIGURE NEW AMORTIZATION COST
D3 ADD COST TO AMORTIZE Q(4) TO REG8
E3 SRDIST 020A3 FIND DISTANCE PQ(9) TO Q(4)
F3 SRTRCST FIND TRANSPORTATION COST
G3 ADD TRANSPORTATION COST TO REG8
H3 SRDIST 020A3 FIND DISTANCE Q(4) TO WGCPSG
J3 SRTRCST FIND TRANSPORTATION COST
K3 ADD TRANSPORTATION COST TO REG8 = TOTAL COST
015 B4
CUP
B4 SET NPTPQF=1 (AT LEAST 1 NON-PROCESSING PQ FOUND)
C4 LOAD EST COST INTO REG7
D4 CONVERT TO PENNIES (*100)
E4 DIVIDE BY LIFE UNPROCESSED S&G
F4 STORE IN AMORT
G4 ADD COST TO MINE TO REG7
H4 SRDIST 020A3 FIND DISTANCE PQ(9) TO WGCUPSG OR Q(4)
J4 SRTRCST FIND TRANSPORTATION COST
K4 ADD TO REG7 = TOTAL COST
G5 IS COST LOWER THAN PREVIOUS LOW COST (COSTCMP3) ?
NO
014 F2
YES
H5 STORE ADDR PQ(9) IN ADDRPQ3
J5 STORE COST IN COSTCMP3
K5 STORE AMORTIZATION COST (AMORT) IN AMORT3
014 F2

SUBROUTINES SRAQ & SRAPQ
ADD QUARRY TO QUARRY CHAIN
ADD POTENTIAL QUARRY TO POTENTIAL QUARRY CHAIN

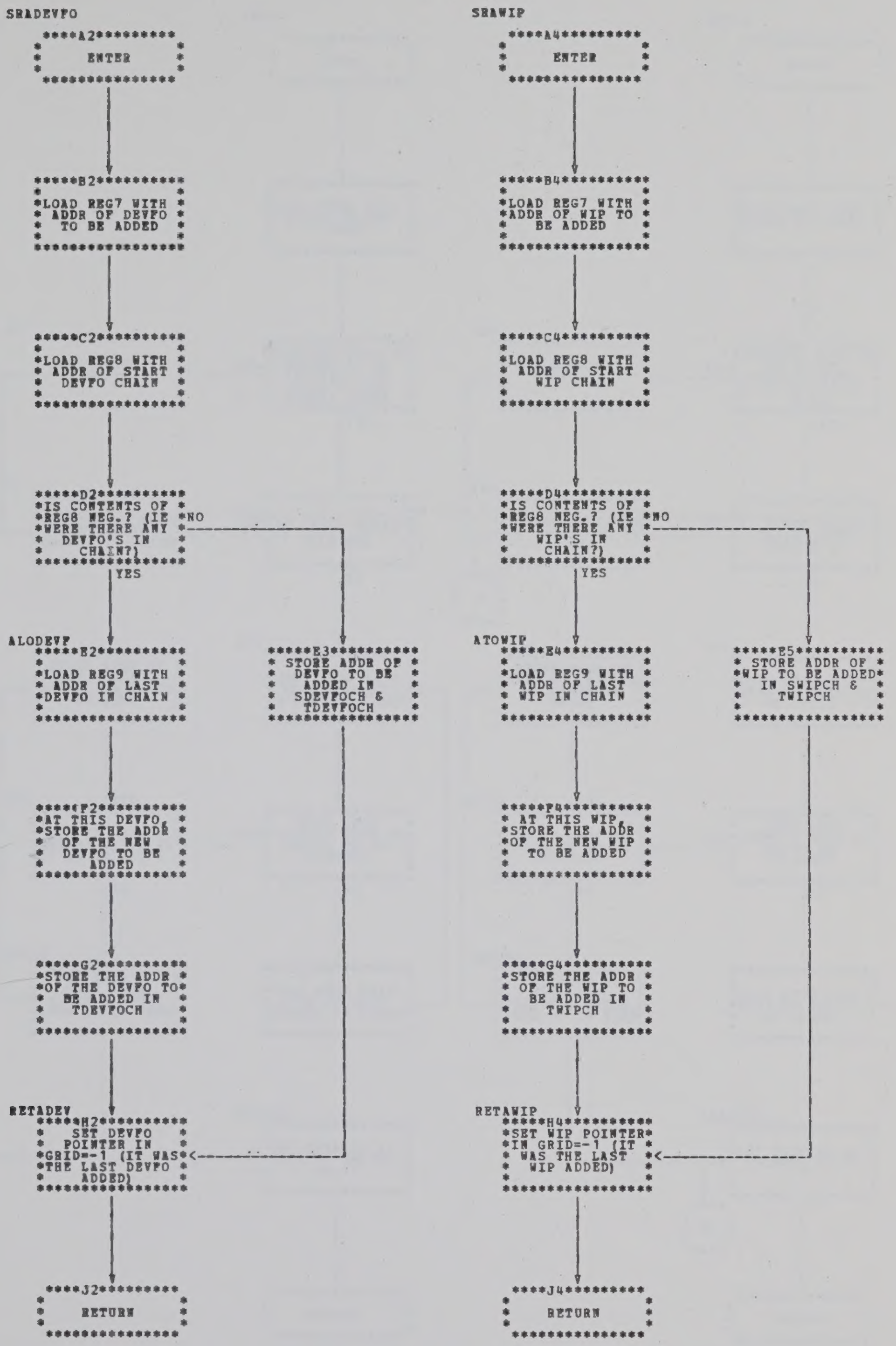

SRAQ
A3
ENTER
SRAPQ
A4
ENTER
ALOQ
B2
LOAD REG9 WITH ADDR OF LAST QUARRY IN CHAIN
B3
LOAD REG7 WITH ADDR OF QUARRY TO BE ADDED
B4
LOAD REG7 WITH ADDR OF PQ TO BE ADDED
C2
AT THIS QUARRY, STORE THE ADDR OF THE NEW QUARRY TO BE ADDED
C3
LOAD REG8 WITH ADDR OF START QUARRY CHAIN
C4
LOAD REG 8 WITH ADDR OF START PQ CHAIN
D2
STORE THE ADDR OF THE QUARRY TO BE ADDED IN TQCH
D3
YES
IS CONTENTS OF REG8 NEG. (IE WERE THERE ANY QUARRYS IN CHAIN)?
NO
D4
IS CONTENTS OF REG8 NEG.? (IE WERE THERE ANY PQ'S IN CHAIN?)
NO
YES
RETAQ
E2
NO
IS OWNER OF QUARRY TO BE ADDED = 00?
YES
E3
STORE ADDR OF QUARRY TO BE ADDED IN SQCH & TQCH
ALOPQ
E4
LOAD REG9 WITH ADDR OF LAST PQ IN CHAIN
E5
STORE ADDR OF PQ TO BE ADDED IN SPQCH & TPQCH
F2
ADD 1 TO OWNER OF LAST Q ADD = NEW OWNER
F4
AT THIS PQ, STORE THE ADDR OF THE NEW PQ TO BE ADDED
G2
SET OWNERSHIP OF NEW QUARRY
G4
STORE THE ADDR OF THE PQ TO BE ADDED IN TPQCH
ISIT1
H2
IS IT THE 1ST Q ADDED DURING YEAR? (IS FQADY=0?)
NO
YES
A
SETADR
H3
SET QUARRY POINTER IN GRID =-1 (IT WAS THE LAST Q ADDED)
RETAPQ
H4
SET PQ POINTER IN GRID =-1 (IT WAS THE LAST PQ ADDED)
J2
STORE ITS ADDR IN FQADY
J3
RETURN
J4
RETURN

[illegible]

[illegible]



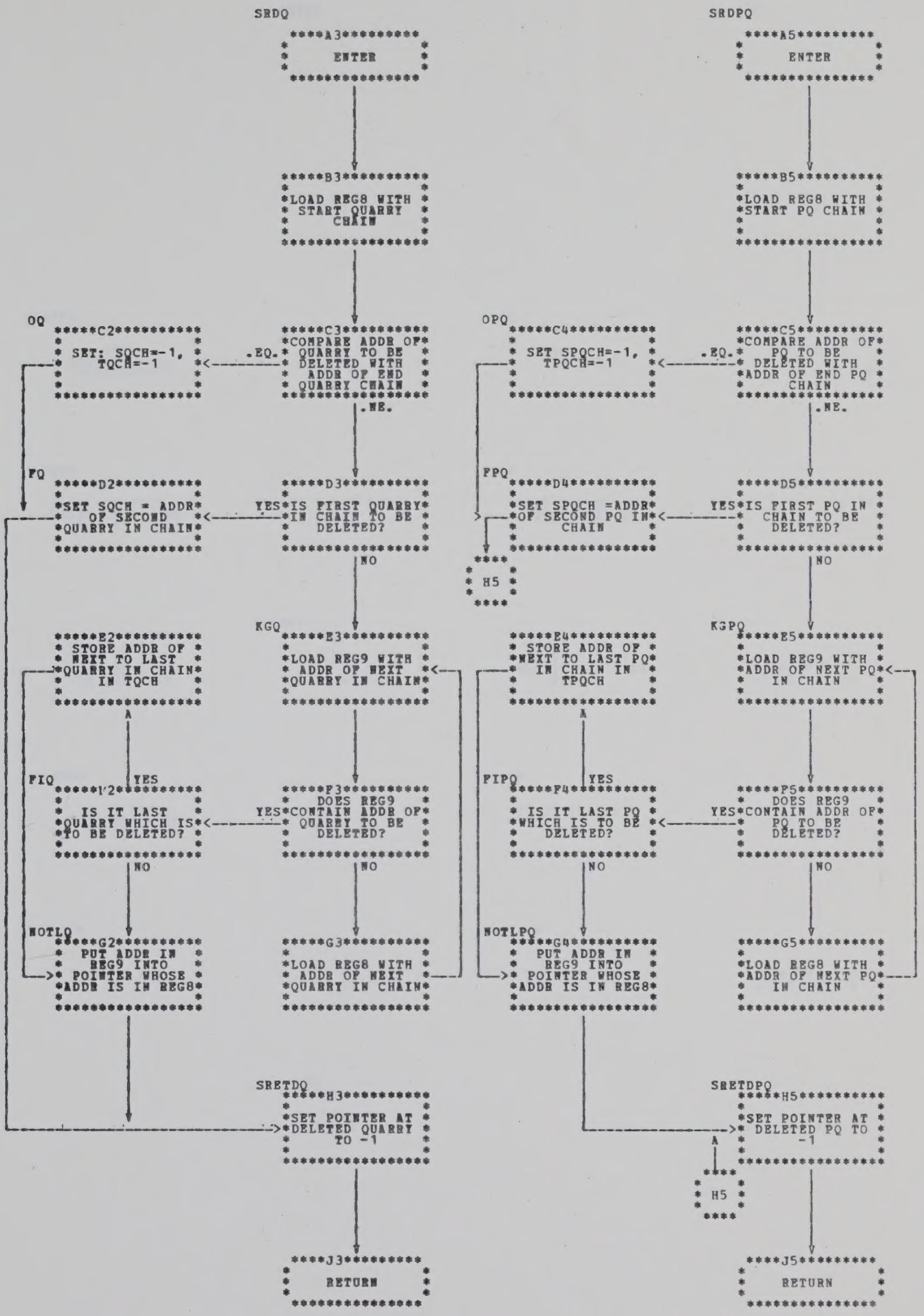
SUBROUTINES SRADEVFO & SRAWIP
ADD DEVELOPMENT FORECASTED TO DEVFO CHAIN
ADD WORK IN PROCESS TO WORK IN PROCESS CHAIN

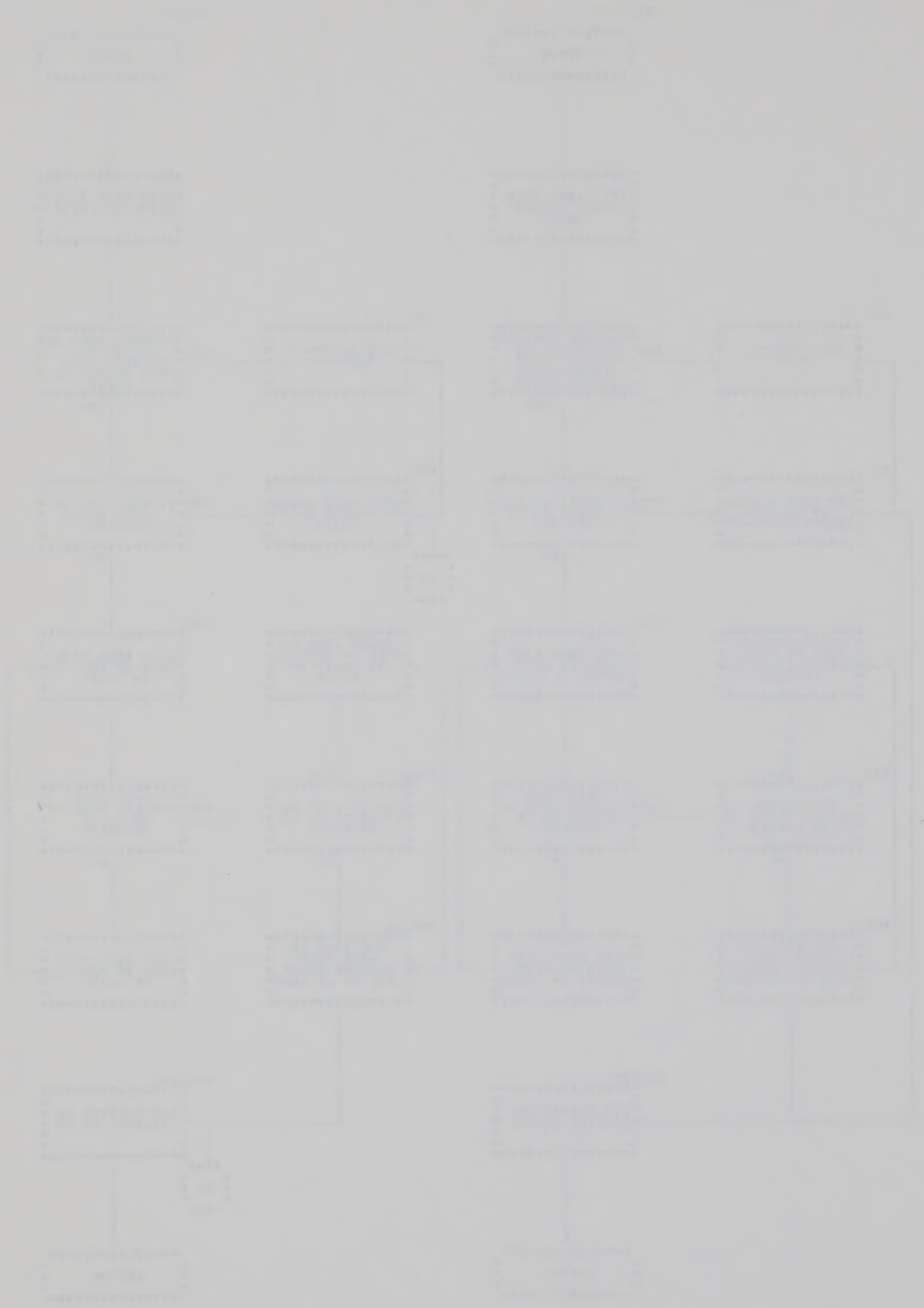

SRADEVFO
A2
ENTER
B2
LOAD REG7 WITH ADDR OF DEVFO TO BE ADDED
C2
LOAD REG8 WITH ADDR OF START DEVFO CHAIN
D2
IS CONTENTS OF REG8 NEG.? (IE WERE THERE ANY DEVFO'S IN CHAIN?)
NO
YES
ALODEVF
E2
LOAD REG9 WITH ADDR OF LAST DEVFO IN CHAIN
E3
STORE ADDR OF DEVFO TO BE ADDED IN SDEVFOCH & TDEVFOCH
F2
AT THIS DEVFO, STORE THE ADDR OF THE NEW DEVFO TO BE ADDED
G2
STORE THE ADDR OF THE DEVFO TO BE ADDED IN TDEVFOCH
RETADEV
H2
SET DEVFO POINTER IN GRID=-1 (IT WAS THE LAST DEVFO ADDED)
J2
RETURN
SRAWIP
A4
ENTER
B4
LOAD REG7 WITH ADDR OF WIP TO BE ADDED
C4
LOAD REG8 WITH ADDR OF START WIP CHAIN
D4
IS CONTENTS OF REG8 NEG.? (IE WERE THERE ANY WIP'S IN CHAIN?)
NO
YES
ATOWIP
E4
LOAD REG9 WITH ADDR OF LAST WIP IN CHAIN
E5
STORE ADDR OF WIP TO BE ADDED IN SWIPCH & TWIPCH
F4
AT THIS WIP, STORE THE ADDR OF THE NEW WIP TO BE ADDED
G4
STORE THE ADDR OF THE WIP TO BE ADDED IN TWIPCH
RETAWIP
H4
SET WIP POINTER IN GRID=-1 (IT WAS THE LAST WIP ADDED)
J4
RETURN

[illegible]

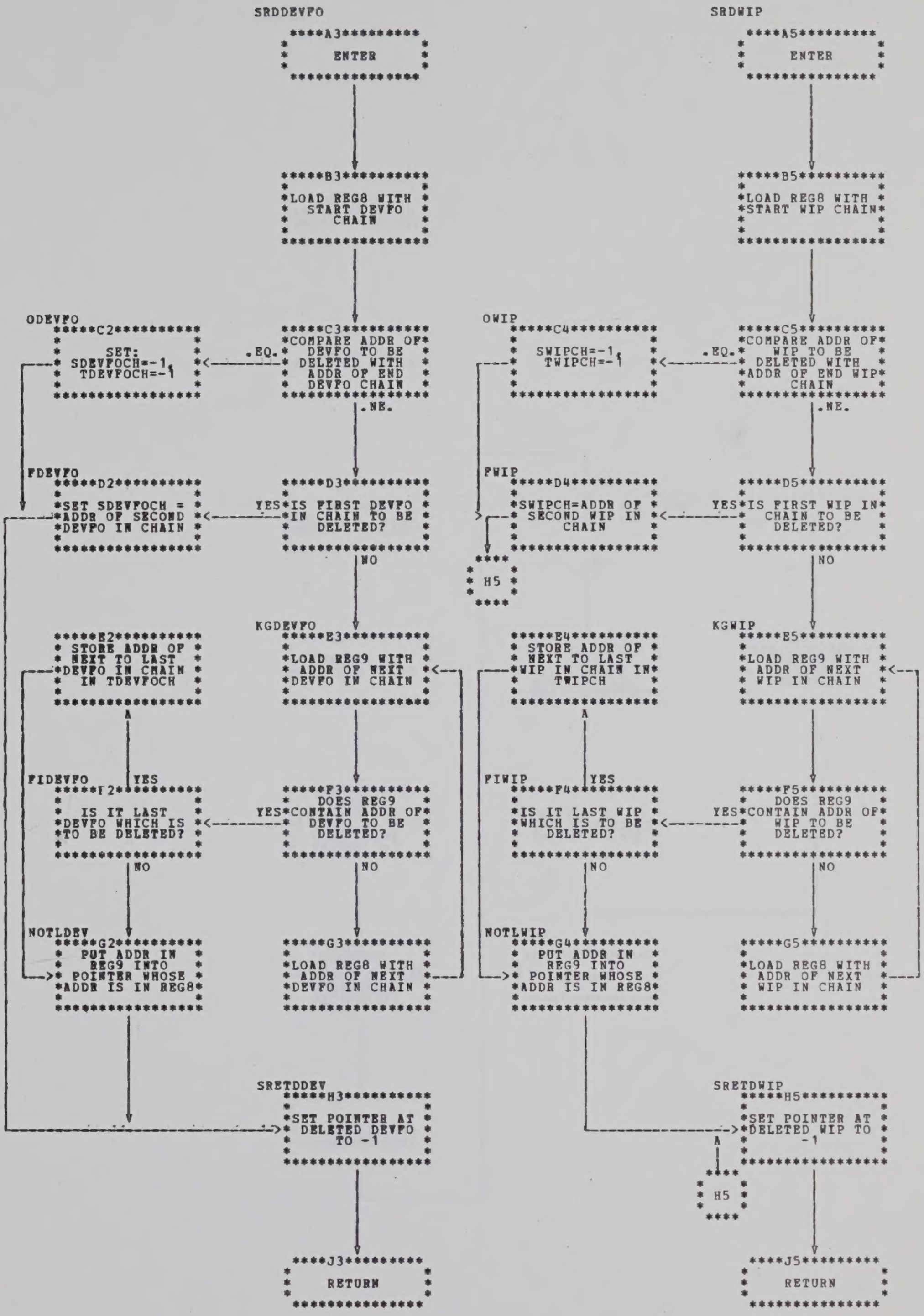
[illegible]

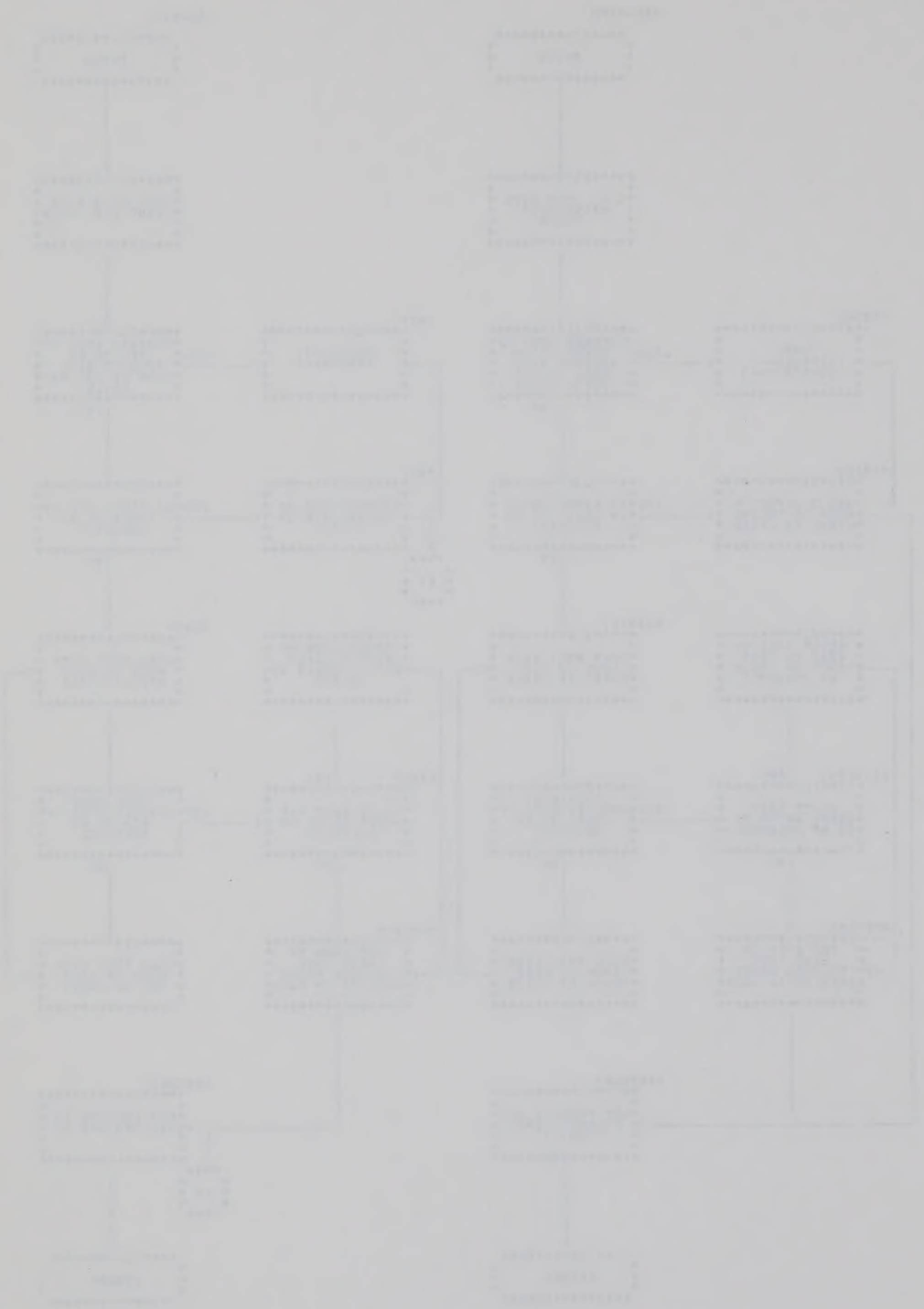
SUBROUTINES SRDQ & SRDPQ
DELETE QUARRY FROM QUARRY CHAIN
DELETE POTENTIAL QUARRY FROM PQ CHAIN


SRDQ
A3 ENTER
B3 LOAD REG8 WITH START QUARRY CHAIN
C3 COMPARE ADDR OF QUARRY TO BE DELETED WITH ADDR OF END QUARRY CHAIN
.EQ.
.NE.
OQ
C2 SET: SQCH=-1, TQCH=-1
FQ
D2 SET SQCH = ADDR OF SECOND QUARRY IN CHAIN
D3 IS FIRST QUARRY IN CHAIN TO BE DELETED?
YES
NO
KGQ
E3 LOAD REG9 WITH ADDR OF NEXT QUARRY IN CHAIN
E2 STORE ADDR OF NEXT TO LAST QUARRY IN CHAIN IN TQCH
FIQ
F2 IS IT LAST QUARRY WHICH IS TO BE DELETED?
F3 DOES REG9 CONTAIN ADDR OF QUARRY TO BE DELETED?
NOTLQ
G2 PUT ADDR IN REG9 INTO POINTER WHOSE ADDR IS IN REG8
G3 LOAD REG8 WITH ADDR OF NEXT QUARRY IN CHAIN
SRETDQ
H3 SET POINTER AT DELETED QUARRY TO -1
J3 RETURN
SRDPQ
A5 ENTER
B5 LOAD REG8 WITH START PQ CHAIN
C5 COMPARE ADDR OF PQ TO BE DELETED WITH ADDR OF END PQ CHAIN
OPQ
C4 SET SPQCH=-1, TPQCH=-1
FPQ
D4 SET SPQCH =ADDR OF SECOND PQ IN CHAIN
H5
D5 IS FIRST PQ IN CHAIN TO BE DELETED?
KGPQ
E5 LOAD REG9 WITH ADDR OF NEXT PQ IN CHAIN
E4 STORE ADDR OF NEXT TO LAST PQ IN CHAIN IN TPQCH
FIPQ
F4 IS IT LAST PQ WHICH IS TO BE DELETED?
F5 DOES REG9 CONTAIN ADDR OF PQ TO BE DELETED?
NOTLPQ
G4 PUT ADDR IN REG9 INTO POINTER WHOSE ADDR IS IN REG8
G5 LOAD REG8 WITH ADDR OF NEXT PQ IN CHAIN
SRETDPQ
H5 SET POINTER AT DELETED PQ TO -1
H5
J5 RETURN

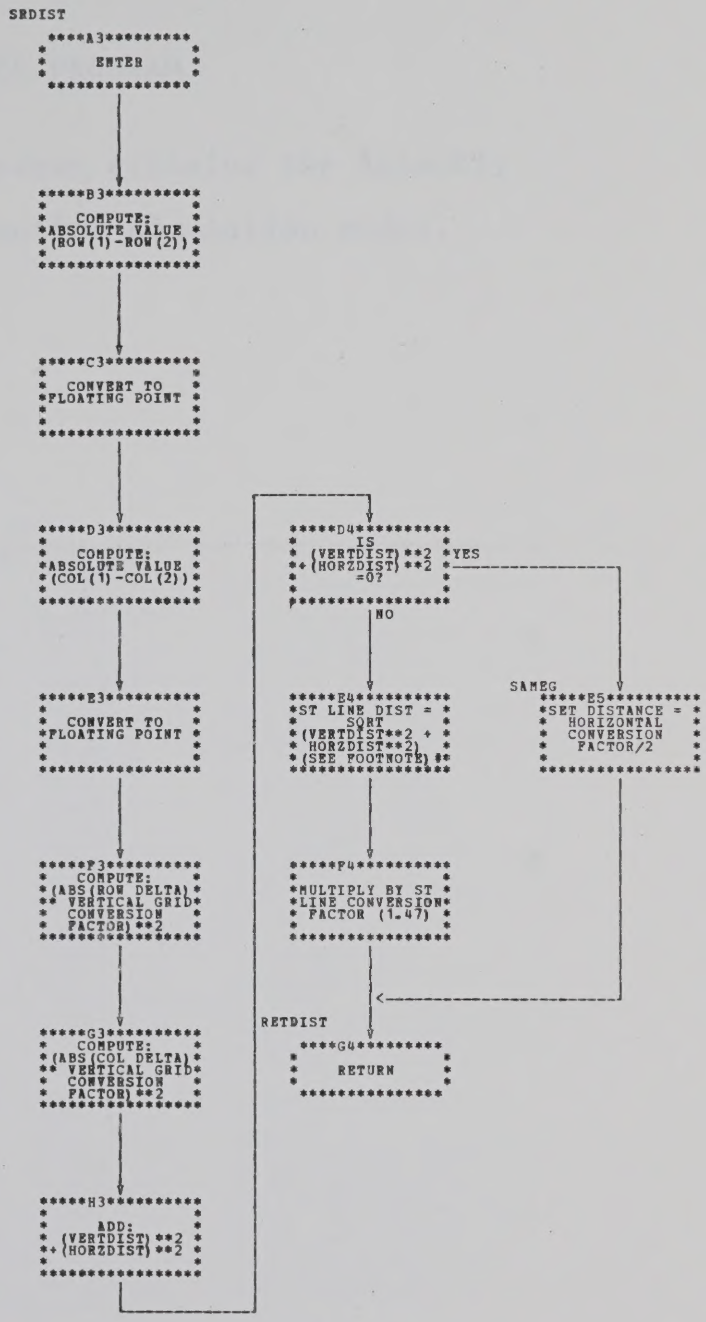


SUBROUTINES SRDDEVFO & SRDWIP
DELETE DEVELOPMENT FORECASTED FROM DEVFO CHAIN
DELETE WORK IN PROCESS FROM WIP CHAIN


SRDDEVFO
A3
ENTER
B3
LOAD REG8 WITH START DEVFO CHAIN
C3
COMPARE ADDR OF DEVFO TO BE DELETED WITH ADDR OF END DEVFO CHAIN
.EQ.
.NE.
ODEVFO
C2
SET: SDEVFOCH=-1, TDEVFOCH=-1
FDEVFO
D2
SET SDEVFOCH = ADDR OF SECOND DEVFO IN CHAIN
D3
IS FIRST DEVFO IN CHAIN TO BE DELETED?
YES
NO
KGDEVFO
E3
LOAD REG9 WITH ADDR OF NEXT DEVFO IN CHAIN
E2
STORE ADDR OF NEXT TO LAST DEVFO IN CHAIN IN TDEVFOCH
FIDEVFO
F2
IS IT LAST DEVFO WHICH IS TO BE DELETED?
YES
NO
F3
DOES REG9 CONTAIN ADDR OF DEVFO TO BE DELETED?
YES
NO
NOTLDEV
G2
PUT ADDR IN REG9 INTO POINTER WHOSE ADDR IS IN REG8
G3
LOAD REG8 WITH ADDR OF NEXT DEVFO IN CHAIN
SRETDDEV
H3
SET POINTER AT DELETED DEVFO TO -1
J3
RETURN
SRDWIP
A5
ENTER
B5
LOAD REG8 WITH START WIP CHAIN
C5
COMPARE ADDR OF WIP TO BE DELETED WITH ADDR OF END WIP CHAIN
.EQ.
.NE.
OWIP
C4
SWIPCH=-1, TWIPCH=-1
FWIP
D4
SWIPCH=ADDR OF SECOND WIP IN CHAIN
H5
D5
IS FIRST WIP IN CHAIN TO BE DELETED?
YES
NO
KGWIP
E5
LOAD REG9 WITH ADDR OF NEXT WIP IN CHAIN
E4
STORE ADDR OF NEXT TO LAST WIP IN CHAIN IN TWIPCH
FIWIP
F4
IS IT LAST WIP WHICH IS TO BE DELETED?
YES
NO
F5
DOES REG9 CONTAIN ADDR OF WIP TO BE DELETED?
YES
NO
NOTLWIP
G4
PUT ADDR IN REG9 INTO POINTER WHOSE ADDR IS IN REG8
G5
LOAD REG8 WITH ADDR OF NEXT WIP IN CHAIN
SRETDWIP
H5
SET POINTER AT DELETED WIP TO -1
H5
J5
RETURN



DETERMINE DISTANCE BETWEEN 2 POINTS



E4. SQUAR E ROOT
FIGURED USING NEWTON'S
APPROXIMATION

APPENDIX D

SOURCE PROGRAM

The following pages contains the Assembly Language listing of the entire simulation model.

```
                                                                                                                    PAGE    1

  LCC  CBJECT CCDE    ADDR1 ADCR2  STMT   SOURCE STATEMENT                                                F01AUG68   5/30/69

0CCCCC                               1 MINESUBR CSECT
                                     2          ENTRY SRAQ,SRAPQ,SRADEVFO,SRAWIP
                                     3          ENTRY SRDQ,SRDPQ,SRDDEVFO,SRDWIP
                                     4          ENTRY                  CARDIN,LINEOUT,SRWGC,SRTRCST
                                     5          ENTRY SRDIST,SRADEPP,SETZL,SETQUAL
                                     6          ENTRY SRPPU
                                     7          ENTRY INDCB,OUTDCB
0C37CC                               8          USING COMMON,2
```

```
     SUBRCUTINE ACD CUARRY TC CUARRY CHAIN                                                                          PAGE    2

  LCC  CBJECT CCDF    ACDR1 ACDR2  STMT   SOURCE STATEMENT                                                F01AUG68   5/30/69

0CCCCC                              10          USING *,15
0CCCCC 90EC DCOC            0CCCC   11 SRAQ     STM   14,12,12(13)
0CCCC4 587C 2C84            03784   12          L     7,AQTBA             LOAD 7 WITH ADDR OF Q TO BE ADDED
0CCCC8 912C 7C05      C00C5         13          TM    5(7),X'20'          IS IT A CS Q
0CCCCC 4710 FC4C            0C040   14          BO    QAACSQ              IF YES GO TO QAACSQ
0C0C1C 9532 7C18      C0018         15          CLI   24(7),50            IS IT AT LEAST 50 PERCENT SAND
0C0014 47B0 F02C            0002C   16          BNL   TGRVL               IF NOT, GO TO TGRVL
0C0018 43B0 2268            03968   17          IC    11,DFAREQPR         DOES FINE AGGREGATE REQ PROC
0C0C1C 44B0 F0A6            000A6   18          EX    11,CIFARPR1         ''
0C0C2C 4780 F048            00048   19          BZ    QAUPSG              IF NOT, GO TO QAUPSG
0CCC24 5C70 211C            0381C   20          ST    7,TYPQASG           STORE ADDR OF Q ADDED IN S&G Q
CC0C28 47F0 F05C            0C050   21          B     L8WSQCH             OTHERWISE, GO TO L8WSQCH
0CCC2C 43B0 2269            03969   22 TGRVL    IC    11,DCAREQPR         DOES COARSE AGGREGATE REQ PR
0CCC3C 44B0 F0AA            0C0AA   23          EX    11,CICARPR1         ''
0C0C34 4780 FC48            0C048   24          BZ    QAUPSG              IF NOT, GO TO QAUPSG
0CC038 507C 211C            0381C   25          ST    7,TYPQASG           STORE ADDR OF Q ADDED IN S&G Q
0C0C3C 47F0 F050            00050   26          B     L8WSQCH             OTHERWISE GO TO L8WSQCH
0CCC40 5C70 2124            03824   27 QAACSQ   ST    7,TYPQACS           STORE ADDR OF CS Q ADDED
0C0C44 47F0 F05C            0C050   28          B     L8WSQCH             GO TO L8WSQSH
0CCC48 507C 212C            03820   29 QAUPSG   ST    7,TYPQAUSG          STORE ADDR OF UNPROCESSED Q ADDED
0C0C4C 47F0 F050            00050   30          B     L8WSQCH             GO TO L8WSQSH
0CCC5C 5880 2C64            03764   31 L8WSQCH  L     8,SQCH              LOAD REG8 WITH START Q CHAIN
0CCC54 1288                         32          LTR   8,8                 TEST ADDR FOR -1
0C0056 472C F066            00066   33          BP    ATLOQ               BRCH ON + TO AT LEAST ONE Q
                                    34 *  AT THIS POINT THERE ARE NO QUARRIES
8C0C5A 5070 2C64            03764   35          ST    7,SQCH              SET STARTING ADDR
0C0C5E 507C 2074            03774   36          ST    7,TQCH              SET END ADDR = START ADDR
0C0062 47F0 F072            00072   37          B     RETAQ               GO TO RETURN
                                    38 *  AT THIS POINT THERE IS AT LEAST ONE QUARRY
0C0066 5890 2C74            03774   39 ATLOQ    L     9,TQCH              LOAD 9 WITH ADDR OF LAST IN CHAIN
0C006A 5C7C 9034            00034   40          ST    7,52(0,9)           STORE ADDR OF Q TO BE ADDED AT
                                    41 *                                  POINTER OF LAST ONE ADDED TO CHAIN
0C006E 5070 2C74            03774   42          ST    7,TQCH              CHANGE ADDR OF LAST ONE ADDED
0CCC72                              43 RETAQ    EQU *
0C0072 95C0 7007      C0007         44          CLI   7(7),X'00'          IS OWNER OF Q BEING ADDED = 00
0C007E 4770 F08C            0008C   45          BNE   ISIT1               IF NOT, GO TO ISIT1
0CC07A 1855                         46          SR    5,5                 CLEAR REG5
0C007C 4350 F0AE            000AE   47          IC    5,HNO               INSERT HIGHEST NO. OWNER INTO REG5
0C008C 415C 5001            0C001   48          LA    5,1(0,5)            ADD 1 TO HIGHEST NO. OWNER
0C0084 425C 7C07            00007   49          STC   5,7(0,7)            SET OWNER IN QUARRY ADDED
0C00B8 4250 F0AE            000AE   50          STC   5,HNO               UPDATE HIGHEST NUMBER OWNER
8C008C 5850 2148            03848   51 ISIT1    L     5,FOADY             LOAD REG5 WITH ADDR FIRST Q ADDED
0C009C 1255                         52          LTR   5,5                 IS ADDR 0 (WAS IT THE FIRST Q)
0C0092 4770 F09A            0009A   53          BNZ   SETADR              IF NOT, GO TO SETADR
                                    54 *  AT THIS POINT, IT IS THE FIRST Q TO BE ADDED DURING THE PERIOD
0CC096 5070 2148            03848   55          ST    7,FQADY             STORE ITS ADDR IN REG7
0C009A C203 7034 2060 C0034 03760   56 SETADR   MVC   52(4,7),MINONE      MAKE ITS POINTER ADDR = -1
0C00A0 98EC DC0C            0C00C   57          LM 14,12,12(13)
0C00A4 C7FE                         58          BR    14
0C00A6 9100 7016      C0016         59 CIFARPR1 TM    22(7),X'00'
0C00AA 9100 7017      CC017         60 CICARPR1 TM    23(7),X'00'
0C00AE 64                           61 HNO      DC    X'64'
000CB0                              62          LTORG
                                    63          DROP  15
                                    64 **********************************************************************
```

```
      SUBRCUTINE ACC POTENTIAL QUARRY TO PQ CHAIN                                                                       PAGE    3

  LCC  CBJECT CCDE    ACDR1 ACCR2  STMT   SOURCE STATEMENT                                                     F01AUG68   5/30/69

 0C0CBC                                   66          USING *,15
 0C0CBC 90EC DC0C            0C00C    67 SRAPQ     STM   14,12,12(13)
 0C00B4 5870 2088            03788    68           L     7,APQTBA          Load REG7 WITH ADDR Q TO BE ADDED
 0C0CB8 5880 2068            03768    69           L     8,SPQCH           LOAD REG8 WITH START Q CHAIN
 0C0CBC 1288                          70           LTR   8,8               ARE THERE ANY Q'S IN CHAIN
 0C0CBE 4720 F01E            000CE    71           BP    ATLOPQ            IF YES, GO TO ATLOPQ
 0C0CC2 5070 2068            03768    72           ST    7,SPQCH           IF NOT, START Q CHAIN
 0C0CC6 5070 2C78            03778    73           ST    7,TPQCH           "
 0C00CA 47F0 F02A            0C0DA    74           B     RETAPQ            GO TO RETAPQ
 0C0CCE 5890 2078            03778    75 ATLOPQ    L     9,TPQCH           ADD Q TO CHAIN
 0C0CD2 5070 9034            00034    76           ST    7,52(0,9)         SET ADDR LAST Q IN CHAIN TO NEW Q
 0C0CD6 5070 2C78            03778    77           ST    7,TPQCH           STORE ADDR NEW Q IN TPQCH
 0C0CDA                               78 RETAPQ    EQU *                   RETURN
 0C0CDA C203 7034 206C C0034 03760    79           MVC   52(4,7),MINONE
 0C0CEC 98EC DC0C            0CCCC    80           LM 14,12,12(13)
 0C0CE4 C7FE                          81           BR    14
 0C0CE8                               82           LTORG
                                      83           DROP  15
                                      84 ****************************************************************************
```

```
      SUBRCUTINE ACC DEVELOPMENT FORECASTED TO DEVFO CHAIN                                                              PAGE    4

  LCC  CBJECT CCDE    ADDR1 ACCR2  STMT   SOURCE STATEMENT                                                     F01AUG68   5/30/69

 0C0CE8                                   86          USING *,15
 0C0CE8 90EC DC0C            0CCCC    87 SRADEVFO  STM   14,12,12(13)
 0CCCEC 5870 2C8C            0378C    88           L     7,ADEVTBA
 0CCCFC 588C 206C            0376C    89           L     8,SDEVFOCH        DOCUMENTATION SAME AS
 0CCCF4 1288                          90           LTR   8,8                  SRAPQ
 0C0CF6 4720 F01E            0C106    91           BP    ATLODEVF
 0C0CFA 5070 206C            0376C    92           ST    7,SDEVFOCH
 0C0CFF 5070 207C            0377C    93           ST    7,TDEVFOCH
 0C01C2 47F0 FC2A            0C112    94           B     RETADEV
 0CC1C6 589C 207C            0377C    95 ATLODEVF  L     9,TDEVFOCH
 0CC1CA 5070 9038            0C038    96           ST    7,56(0,9)
 0CC1CE 507C 207C            0377C    97           ST    7,TDEVFOCH
 0C0112                               98 RETADEV   EQU   *
 0C0112 C203 7038 2C6C CC038 03760    99           MVC   56(4,7),MINONE
 0CC118 98EC DC0C            0C0C0   100           LM 14,12,12(13)
 0CC11C C7FE                         101           BR    14
 0CC12C                              102           LTORG
                                     103           DROP  15
                                     104 ****************************************************************************
```

```
      SUBRCUTINE ACC WORK IN PRCCESS TO WIP CHAIN                                                                       PAGE    5

  LCC  OBJECT CCDE    ACDR1 ACCR2  STMT   SOURCE STATEMENT                                                     F01AUG68   5/30/69

 00012C                                  106          USING *,15
 0CC12C 90EC D00C            0CC0C   107 SRAWIP    STM   14,12,12(13)
 0CC124 587C 209C            03790   108           L     7,AWIPTBA
 0C0128 588C 2C7C            03770   109           L     8,SWIPCH
 0C012C 1288                         110           LTR   8,8               DOCUMENTATION SAME AS
 0C012E 4720 F01E            0013E   111           BP    ATLOWIP              SRAPQ
 0C0132 5070 2C70            03770   112           ST    7,SWIPCH
 0C0136 5070 208C            03780   113           ST    7,TWIPCH
 0CC13A 47FC F02A            0014A   114           B     RETAWIP
 0C013E 5890 208C            03780   115 ATLOWIP   L     9,TWIPCH
 000142 5070 903C            0003C   116           ST    7,60(0,9)
 0C0146 5070 2080            03780   117           ST    7,TWIPCH
 0C014A                              118 RETAWIP   EQU   *
 0C014A D2C3 703C 2060 C003C 03760   119           MVC   60(4,7),MINONE
 0C015C 98EC D00C            0000C   120           LM 14,12,12(13)
 0C0154 07FE                         121           BR    14
 0C0158                              122           LTORG
                                     123           DROP  15
                                     124 ****************************************************************************
```

```
     SUBROUTINE DELETE QUARRY FROM QUARRY CHAIN                                                          PAGE    6

  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                     F01AUG68   5/30/69

000158                               126          USING *,15
000158 90EC D00C             0000C   127 SRDQ     STM   14,12,12(13)
00015C 5880 2064             03764   128          L     8,SQCH                 LOAD 8 WITH ADDR OF BEG Q CHAIN
000160 5580 2074             03774   129          CL    8,TQCH                 IS THERE ONLY ONE Q
000164 4780 F02A             00182   130          BE    OQ                     IF SO, GO TO ONE Q
                                     131 *  AT THIS POINT THERE ARE AT LEAST TWO QUARRIES
000168 5580 2094             03794   132          CL    8,AQTBD                SEE IF FIRST Q IN CH TO BE DELETED
00016C 4780 F03A             00192   133          BE    FQ                     IF SO, GO TO FIRST Q
                                     134 *  AT THIS POINT THERE ARE MORE THAN 1 Q'S & IT IS NOT 1ST Q TO BE DEL
000170 5890 8034             00034   135 KGQ      L     9,52(0,8)              LOAD 9 WITH ADDR OF NEXT Q
000174 5590 2094             03794   136          CL    9,AQTBD                SEE IF Q WHOSE ADDR IS IN 8 IS TBD
000178 4780 F044             0019C   137          BE    FIQ                    IF SO GO TO FIND Q
00017C 1889                          138          LR    8,9                    UPDATE 8 WITH ADDR OF NEXT Q
00017E 47F0 F018             00170   139          B     KGQ                    BRANCH TO KEEP GOING
                                     140 *  AT THIS POINT THERE WAS ONLY ONE Q AND IT IS TO BE DELETED
000182 D203 2064 2060 03764 03760    141 OQ       MVC   SQCH,MINONE            SET SQCH = -1
000188 D203 2074 2060 03774 03760    142          MVC   TQCH,MINONE            SET TQCH = -1
00018E 47F0 F05A             001B2   143          B     SRETDQ                 GO TO RETURN ROUTINE
                                     144 *  AT THIS POINT, FIRST Q IN CHAIN MUST BE DELETED
000192 D203 2064 8034 03764 00034    145 FQ       MVC   SQCH,52(8)             CHANGE SQCH TO NEW STARTING ADDR
000198 47F0 F05A             001B2   146          B     SRETDQ                 GO TO RETURN ROUTINE
                                     147 *  AT THIS POINT WE HAVE FOUND Q TO BE DELETED.  ITS ADDR IS IN REG 9
                                     148 *   WHILE ADDR OF PRECEDING Q IS IN REG 8
00019C D503 9034 2060 00034 03760    149 FIQ      CLC   52(4,9),MINONE         SEE IF IT LAST Q TO BE DELETED
0001A2 4770 F052             001AA   150          BNE   NOTLQ                  IF NOT, GO TO NOT LAST Q
                                     151 *  AT THIS POINT IT IS THE LAST Q TO BE DELETED
0001A6 5080 2074             03774   152          ST    8,TQCH                 STORE ADDR OF NEW LAST IN TQCH
0001AA D203 8034 9034 00034 00034    153 NOTLQ    MVC   52(4,8),52(9)          CHANGE POINTER ADDR IN PRECEDING Q
0001B0 1889                          154          LR    8,9                    LOAD ADDR TO BE DELETED IN 8
0001B2 D203 8034 2060 00034 03760    155 SRETDQ   MVC   52(4,8),MINONE         MAKE POINTER IN Q TO BE DELETED -1
0001B8 98EC D00C             0000C   156          LM 14,12,12(13)
0001BC 07FE                          157          BR    14
0001C0                               158          LTORG
                                     159          DROP  15
                                     160 *****************************************************************
```

```
     SUBROUTINE DELETE POTENTIAL QUARRY FROM PQ CHAIN                                                    PAGE    7

  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                     F01AUG68   5/30/69

0001C0                               162          USING *,15
0001C0 90EC D00C             0000C   163 SRDPQ    STM   14,12,12(13)
0001C4 5880 2068             03768   164          L     8,SPQCH
0001C8 5580 2078             03778   165          CL    8,TPQCH
0001CC 4780 F02A             001EA   166          BE    OPQ
0001D0 5580 2098             03798   167          CL    8,APQTBD
0001D4 4780 F03A             001FA   168          BE    FPQ
0001D8 5890 8034             00034   169 KGPQ     L     9,52(0,8)
0001DC 5590 2098             03798   170          CL    9,APQTBD
0001E0 4780 F044             00204   171          BE    FIPQ
0001E4 1889                          172          LR    8,9
0001E6 47F0 F018             001D8   173          B     KGPQ
0001EA D203 2068 2060 03768 03760    174 OPQ      MVC   SPQCH,MINONE
0001F0 D203 2078 2060 03778 03760    175          MVC   TPQCH,MINONE
0001F6 47F0 F05A             0021A   176          B     SRETDPQ
0001FA D203 2068 8034 03768 00034    177 FPQ      MVC   SPQCH,52(8)
000200 47F0 F05A             0021A   178          B     SRETDPQ
000204 D503 9034 2060 00034 03760    179 FIPQ     CLC   52(4,9),MINONE
00020A 4770 F052             00212   180          BNE   NOTLPQ
00020E 5080 2078             03778   181          ST    8,TPQCH
000212 D203 8034 9034 00034 00034    182 NOTLPQ   MVC   52(4,8),52(9)
000218 1889                          183          LR    8,9
00021A D203 8034 2060 00034 03760    184 SRETDPQ  MVC   52(4,8),MINONE
000220 98EC D00C             0000C   185          LM 14,12,12(13)
000224 07FE                          186          BR    14
000228                               187          LTORG
                                     188          DROP  15
                                     189 *****************************************************************
```

DOCUMENTATION SAME AS
SRDQ

```
     SUBROUTINE DELETE DEVELOPMENT FORECASTED FROM DEVFO CH                                              PAGE    8

  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                     F01AUG68   5/30/69

000228                               191          USING *,15
000228 90EC D00C             0000C   192 SRDDEVFO STM   14,12,12(13)
00022C 5880 206C             0376C   193          L     8,SDEVFOCH
000230 5580 207C             0377C   194          CL    8,TDEVFOCH
000234 4780 F02A             00252   195          BE    ODEVFO
000238 5580 209C             0379C   196          CL    8,ADEVTBD
00023C 4780 F03A             00262   197          BE    FDEVFO
000240 5890 8038             00038   198 KGDEVFO  L     9,56(0,8)
000244 5590 209C             0379C   199          CL    9,ADEVTBD
000248 4780 F044             0026C   200          BE    FIDEVFO
00024C 1889                          201          LR    8,9
00024E 47F0 F018             00240   202          B     KGDEVFO
000252 D203 206C 2060 0376C 03760    203 ODEVFO   MVC   SDEVFOCH,MINONE
000258 D203 207C 2060 0377C 03760    204          MVC   TDEVFOCH,MINONE
00025E 47F0 F05A             00282   205          B     SRETDDEV
000262 D203 206C 8038 0376C 00038    206 FDEVFO   MVC   SDEVFOCH,56(8)
000268 47F0 F05A             00282   207          B     SRETDDEV
00026C D503 9038 2060 00038 03760    208 FIDEVFO  CLC   56(4,9),MINONE
000272 4770 F052             0027A   209          BNE   NOTLDEV
000276 5080 207C             0377C   210          ST    8,TDEVFOCH
00027A D203 8038 9038 00038 00038    211 NOTLDEV  MVC   56(4,8),56(9)
000280 1889                          212          LR    8,9
000282 D203 8038 2060 00038 03760    213 SRETDDEV MVC   56(4,8),MINONE
000288 98EC D00C             0000C   214          LM 14,12,12(13)
00028C 07FE                          215          BR    14
000290                               216          LTORG
                                     217          DROP  15
                                     218 *****************************************************************
```

DOCUMENTATION SAME AS
SRDQ

```
      SUBROUTINE DELETE WORK IN PROCESS FROM WIP CHAIN                                                  PAGE    9

  LCC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                  F01AUG68   5/30/69

0C029C                             220          USING *,15
0C0290 90EC D00C            0C00C  221 SRDWIP   STM   14,12,12(13)
0C0294 5880 207C            03770  222          L     8,SWIPCH
0C0298 558C 2080            03780  223          CL    8,TWIPCH
0CC29C 4780 FC2A            0028A  224          BE    OWIP
0C02AC 5580 2CAC            037A0  225          CL    8,AWIPTBD
0C02A4 4780 F03A            002CA  226          BE    FWIP
0C02A8 5890 803C            0003C  227 KGWIP    L     9,60(0,8)
0C02AC 5590 2CAC            037A0  228          CL    9,AWIPTBD
0C02BC 4780 F044            002D4  229          BE    FIWIP
0C02B4 1889                        230          LR    8,9
0C02B6 47FC F018            002A8  231          B     KGWIP
0C02BA D203 2070 2060 03770 03760  232 OWIP     MVC   SWIPCH,MINONE
0C02CC D203 2080 2060 03780 03760  233          MVC   TWIPCH,MINONE
0C02C6 47FC F05A            002EA  234          B     SRETDWIP
0C02CA D203 2070 8C3C 03770 0003C  235 FWIP     MVC   SWIPCH,60(8)
0C02DC 47FC FC5A            002EA  236          B     SRETDWIP
0002D4 D503 903C 2C60 0003C 03760  237 FIWIP    CLC   60(4,9),MINONE
0C02DA 4770 F052            002E2  238          BNE   NOTLWIP
0C02DE 508C 2C8C            03780  239          ST    8,TWIPCH
0C02E2 D2C3 803C 903C C003C 0003C  240 NOTLWIP  MVC   60(4,8),60(9)
0C02E8 1889                        241          LR    8,9
0C02EA C203 803C 2060 CC03C 03760  242 SRETDWIP MVC   60(4,8),MINONE
0C02F0 98EC D00C            0C00C  243          LM 14,12,12(13)
0C02F4 C7FE                        244          BR    14
0C02F8                             245          LTORG
                                   246          DROP  15
                                   247 ***********************************************************************
```

DOCUMENTATION SAME AS
SRDQ

```
      SUBROUTINE FCR DETERMINING DISTANCES BETWEEN 2 POINTS                                             PAGE   10

  LCC  OBJECT CODE    ADDR1 ACDR2  STMT   SOURCE STATEMENT                                  F01AUG68   5/30/69

                                   249 *  PARAMETERS ARE POINT1 & POINT2 WHICH ARE THE ROWS & COLUMNS OF THE
                                   250 *   TWO POINTS BETWEEN WHICH THE DISTANCE IS TO BE DETERMINED
                                   251 *   AND DISTX WHICH IS THE CALCULATED DISTANCE BETWEEN THE POINTS
                                   252 *   CORRECTED BY THE CROW FLY-ACTUAL FACTOR (IN FLOATING POINT)
0C02F8                             253          USING *,15
0C02F8 90EC DC0C            0000C  254 SRDIST   STM   14,12,12(13)
0C02FC 702C F0BC            003A8  255          STE   2,FP2                 SAVE FLT PT REGISTERS
0C03CC 704C FCB4            003AC  256          STE   4,FP4                 ''
0CC304 706C FCB8            003B0  257          STE   6,FP6                 ''
0C03C8 1844                        258          SR    4,4                   CLEAR REG 4
0C030A 1B55                        259          SR    5,5                   CLEAR REG 5
0CC30C 4840 2C8C            037B0  260          LH    4,POINT1              LOAD ROW OF POINT 1 IN REG 4
00031C 485C 20B4            037B4  261          LH    5,POINT2              LOAD ROW OF POINT 2 IN REG 5
0CC314 1854                        262          SR    5,4                   SUBTRACT 4 FROM 5 AND PLACE IN 5
0C0316 1055                        263          LPR   5,5                   TAKE ABSOLUTE VALUE OF DIFFERENCE
0C0318 505C FCC8            003C0  264          ST    5,VDISTFP             STORE  5 IN VERTICAL DISTANCE
0C031C 9646 F0C8      003C0        265          OI    VDISTFP,X'46'         CONVERT TO FLOATING POINT
0C032C 1844                        266          SR    4,4                   CLEAR 4
0C0322 1855                        267          SR    5,5                   CLEAR 5
000324 4840 2082            03782  268          LH    4,POINT1+2            LOAD COL POINT 1 IN REG 4
0C0328 4850 2086            03786  269          LH    5,POINT2+2            LOAD COL POINT 2 IN REG 5
0CC32C 1854                        270          SR    5,4
0C032E 1055                        271          LPR   5,5
0C0330 5050 F0CC            003C4  272          ST    5,HDISTFP
0C0334 9646 FCCC      003C4        273          OI    HDISTFP,X'46'
000338 7820 F0C8            003C0  274          LE    2,VDISTFP             LOAD FP REG 2 WITH VERT DIST
0CC33C 7C20 225C            0395C  275          ME    2,VGCONF              MULT BY VERT GRID CONVERS FACTOR
0C0340 3C22                        276          MER   2,2                   SQUARE CONVERTED DISTANCE
0C0342 7840 FCCC            003C4  277          LE    4,HDISTFP             LOAD FP REG 4 WITH HORIZ DIST
0C0346 7C40 2258            03958  278          ME    4,HGCONF              MULT BY HORIZ GRID CONF
0C034A 3C44                        279          MER   4,4                   SQUARE CONVERTED DISTANCE
0CC34C 3A42                        280          AER   4,2                   FP REG 4 CONTAINS A**2 +B**2
0C034E 4780 F092            0038A  281          BZ    SAMEG
0C0352 7040 F0CC            003B8  282          STE   4,NUMBX               STORE ORIGINAL NO IN NUMBX
0C0356 3424                        283          HER   2,4                   DIVIDE NO BY 2 FOR FIRST APPROX
0C0358 7840 F0C0            003B8  284 SQTLOOP  LE    4,NUMBX               LOAD NUMBER INTO REG 4
0C035C 3D42                        285          DER   4,2                   DIVIDE NO BY OLDX
0C035E 3A42                        286          AER   4,2                   ADD OLDX TO NO/OLDX
0C036C 3444                        287          HER   4,4                   1/2(OLDX+NO/OLDX)
0C0362 704C F0BC            003B4  288          STE   4,NEWX                STORE NEW APPROX IN NEWX
0C0366 3B42                        289          SER   4,2                   FIND DELTA
0C0368 3044                        290          LPER  4,4                   MAKE DELTA POSITIVE
0C036A 7B4C F0C4            003BC  291          SE    4,DIFFX               CHECK MAGNITUDE OF DELTA
00036E 47D0 F082            0037A  292          BNP   DISTDET               IF NOT +, GO TO DISTANCE DETERMINED
0C0372 7820 F0BC            003B4  293          LE    2,NEWX                SET NEWX = OLDX AND LOAD IN 2
000376 47F0 F060            00358  294          B     SQTLOOP               GO TO LOOP
0C037A 7860 F0BC            003B4  295 DISTDET  LE    6,NEWX                LOAD DISTANCE INTO 6
0C037E 7C60 2260            03960  296          ME    6,SLCONF              MULT ACTUAL STRAIGHT LINE DISTANCE
                                   297 *                                    BY ST LINE CONVERSION FACTOR
0C0382 7060 20A4            037A4  298          STE   6,DISTX               LOAD DISTANCE INTO DISTX
000386 47F0 F09E            00396  299          B     RETDIST
0C038A 786C 2258            03958  300 SAMEG    LE    6,HGCONF              LOAD HORZ GRID CONF INTO REG 6
0C038E 7D6C FCDC            003C8  301          DE    6,=E'2'               DIVIDE BY 2
000392 7C60 20A4            037A4  302          STE   6,DISTX               STORE DISTANCE IN DISTX
0C0396 782C F0B0            003A8  303 RETDIST  LE    2,FP2                 RESTORE FLT PT REGISTERS
0C039A 7840 F0B4            003AC  304          LE    4,FP4                 ''
0C039E 7860 F0B8            003B0  305          LE    6,FP6                 ''
0C03A2 98EC D00C            0C00C  306          LM    14,12,12(13)
0C03A6 07FE                        307          BR    14
0003A8                             308 FP2      DS    F
0C03AC                             309 FP4      DS    F
0C03BC                             310 FP6      DS    F
0C03B4                             311 NEWX     DS    F
0C03B8                             312 NUMBX    DS    E
0003BC 3F147AE1                    313 DIFFX    DC    E'.005'
0003CC                             314 VDISTFP  DS    F
0C03C4                             315 HDISTFP  DS    F
0CC3C8                             316          LTORG
0003C8 412CC000                    317                =E'2'
                                   318          DROP  15
                                   319 ***********************************************************************
```

SUBROUTINE DETERMINE TRANSPORTATION COST

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                  F01AUG68   5/30/69

                                   321 *  THIS SUBROUTINE DETERMINES TRANSPORTATION COST (IN PENNIES)
                                   322 *   PER TON OF MATERIAL
                                   323 *  IN PARAMETER = TRANSD(TRANSPORT DISTANCE IN FLOATING POINT)
                                   324 *  OUT PARAMETER = FIXPTCST = TRANSPORTATION COST / TON (FIXED POINT)
0C03CC                             325           USING *,15
0C03CC                             326 SRTRCST   EQU   *
0C03CC 90EC D00C          0000C    327           STM   14,12,12(13)
0C03DC 702C FC5C          0041C    328           STE   2,FLT2              STORE FLT PT REGISTERS
0C03D4 782C 20C4          037C4    329           LE    2,TRANSD            LOAD FLTPTR2 WITH DISTANCE
0C03D8 7A2C F05C          00428    330           AE    2,=E'.5'            ADD .5 FOR ROUNDING
0C03DC 7E2C F060          0042C    331           AU    2,=X'46000000'      RIGHT JUSTIFY DISTANCE
0003EC 702C FC54          00420    332           STE   2,DISTTBT           STORE IN DISTANCE TO BE TRANSLATED
0C03E4 9400 FC54    C0420          333           NI    DISTTBT,X'00'       CONVERT TO FIXED POINT
0003E8 D2C0 F058 F057 00424 00423  334           MVC   DINDEX(1),DISTTBT+3 MOVE LOW ORDER BYTE TO DINDEX
0C03EE 953F F058    C0424          335           CLI   DINDEX,63           IS DISTANCE GREATER THAN 63 MILES
0C03F2 47DC F02E          003FA    336           BNH   DTR                 IF NOT, GO TO DTR
0C03F6 923F FC58    C0424          337           MVI   DINDEX,63           OTHERWISE SET DISTANCE = 63 MILES
0C03FA 1877                        338 DTR       SR    7,7                 CLEAR REG7
0C03FC 1B66                        339           SR    6,6                 CLEAR REG6
0C03FE 437C FC58          00424    340           IC    7,DINDEX            INSERT MILAGE INTO REG7
0CC4C2 5C6C FC64          00430    341           M     6,=F'2'             MULT BY 2 TO FIND CORRECT HALFWORD
0CC406 4867 21D4          038D4    342           LH    6,TRCOST(7)         MOVE TRANSPORTATION COST TO REG6
0C04CA 4A6C 2264          03964    343           AH    6,COSTINT           ADD INTERCEPT OPTION
0C04CE 5C6C 20C8          037C8    344           ST    6,FIXPTCST          AND STORE IN FIXPTCST
0CC412 782C FC5C          0041C    345           LE    2,FLT2              RESTORE FLT PT REGISTERS
0CC416 98EC DCCC          0C00C    346           LM    14,12,12(13)
0CC41A C7FE                        347           BR    14
0CC41C                             348 FLT2      DS    F
0CC42C                             349 DISTTBT   DS    F
0CC424                             350 DINDEX  DS      X
0CC428                             351           LTORG
0CC428 408CCCC0                    352                 =E'.5'
0CC42C 460CCCCC                    353                 =X'46000000'
0CC43C CCCCC002                    354                 =F'2'
                                   355           DROP  15
                                   356 ***********************************************************************
```

SUBROUTINE ALLOWANCE ON EXISTING PROCESSING PLANT

```
  LCC  CBJECT CCDE    ACDR1 ACDR2  STMT   SOURCE STATEMENT                                  F01AUG68   5/30/69

                                   358 *  THIS SUBROUTINE DETERMINES THE ALLOWANCE ON THE COST OF A NEW
                                   359 *  PROCESSING PLANT BECAUSE OF MOVING THE EXISTING PROCESSING PLANT
                                   360 *  TO THE NEW LOCATION
                                   361 *         INPUT PARAMETER  - APPTBM (ADDR PP TO BE MOVED)
                                   362 *         OUTPUT PARAMETER - AOEPP (ALLOWANCE ON EXISTING PROC PLANT)
                                   363 *                                     (AOEPP IS A NUMBER WHICH WHEN
                                   364 *                                     MULTIPLIED BY THE COST OF A NEW PP
                                   365 *                                     AND DIVIDED BY 10 GIVES THE NEW COST
0C0434                             366           USING *,15
0C0434 90EC DCCC          0C00C    367 SRAOEPP   STM   14,12,12(13)
0C0438 584C 2CDC          037D0    368           L     4,APPTBM            LOAD REG4 WITH ADDR PP TO BE MOVED
0C043C 9505 402A    C002A          369           CLI   42(4),5             IS REMAINING LIFE .LT. 5 YEARS
0C044C 474C FC2A          0045E    370           BL    LT5YR               IF YES, GO TO LT5YR
0CC444 95CA 4C2A    C002A          371           CLI   42(4),10            IS REMAINING LIFE .LT. 10 YEARS
0C0448 474C FC34          00468    372           BL    LT10YR              IF YES, GO TO LT10YR
0CC44C 95CF 402A    C002A          373           CLI   42(4),15            IS REMAINING LIFE .LT. 15 YEARS
0CC45C 474C FC3E          00472    374           BL    LT15YR              IF YES, GO TO LT15YR
                                   375 *  AT THIS POINT, REMAINING LIFE IS GREATER THAN OR = TO 15 YEARS
0C0454 D203 20CC FC58 C37CC 0048C  376           MVC   AOEPP(4),AOGE15PP   MOVE ALLOWANCE TO ALL ON EXIST PP
0CC45A 47FC F044          00478    377           B     ALLFIG              GO TO ALLOWANCE FIGURED
0C045E D203 20CC F04C 037CC 00480  378 LT5YR     MVC   AOEPP(4),AOLT5PP              ''
0CC464 47FC F044          00478    379           B     ALLFIG              ''
0CC468 D203 2CCC FC50 037CC 00484  380 LT10YR    MVC   AOEPP(4),AOLT10PP             ''
0CC46E 47FC F044          00478    381           B     ALLFIG              ''
0C0472 D203 20CC FC54 037CC 00488  382 LT15YR    MVC   AOEPP(4),AOLT15PP             ''
0CC478                             383 ALLFIG    EQU   *                   (ALLOWANCE FIGURED)
0CC478 98EC DCOC          0C00C    384           LM    14,12,12(13)
0C047C C7FE                        385           BR    14
0CC47E C0CC
0CC48C CCCCCC03                    386 AOLT5PP   DC    F'3'                30( SAVINGS
0CC484 CCCCCCC4                    387 AOLT10PP  DC    F'4'                40( SAVINGS
0CC488 CCCCCC06                    388 AOLT15PP  DC    F'6'                60( SAVINGS
0CC48C CCCCCOC7                    389 AOGE15PP  DC    F'7'                70( SAVINGS
0C049C                             390           LTORG
                                   391           DROP  15
                                   392 ***********************************************************************
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                  F01AUG68   5/30/69

0C049C                              394 SETZL    EQU   *                   (SET ZONING LAW BIT CONFIGURATION)
0C049C                              395          USING *,15
0C049C 96FC 23F8      03AF8         396          OI    ZLAW,X'F0'          MAKE A BLANK A TRUE 0
0C0494 95FC 23F8      03AF8         397          CLI   ZLAW,X'F0'          IS ZONING LAW 0
0C0498 478C F044            004D4   398          BE    ZLNZ                IF 0, GO TO SET MASK = NO ZONING
0C049C 95F1 23F8      03AF8         399          CLI   ZLAW,X'F1'          IS ZONING LAW 1
0C04AC 4780 F04C            004DC   400          BE    ZLNQNPP             IF 1 SET MASK = NO Q, NO PP
0C04A4 95F2 23F8      03AF8         401          CLI   ZLAW,X'F2'          IS ZONING LAW 2
0C04A8 478C F052            004E2   402          BE    ZLQPP               IF 2, SET MASK = +, PP
0C04AC 95F3 23F8      C3AF8         403          CLI   ZLAW,X'F3'          IS ZONING LAW 3
0C04BC 478C F058            004E8   404          BE    ZLQPPS              IF 3, SET MASK = Q, PP (SPECIAL)
0C04B4 95F4 23F8      C3AF8         405          CLI   ZLAW,X'F4'          IS ZONING LAW 4
0C04B8 4780 F05E            004EE   406          BE    ZLNQPP              IF 4, SET MASK = NO Q, PP
0C04BC 95F5 23F8      C3AF8         407          CLI   ZLAW,X'F5'          IS ZONING LAW 5
0C04CC 4780 F064            004F4   408          BE    ZLNQPPS             IF 5, SET MASK = NO Q, PP (SPECIAL)
0C04C4 95F6 23F8      C3AF8         409          CLI   ZLAW,X'F6'          IS ZONING LAW 6
0C04C8 4780 F06A            004FA   410          BE    ZLQNPP              IF 6, SET MASK = Q, NO PP
0C04CC 95F7 23F8      03AF8         411          CLI   ZLAW,X'F7'          IS ZONING LAW 7
0C04CC 4780 FC7C            00500   412          BE    ZLQNPPS             IF 7, SET MASK = Q, NO PP (SPECIAL)
0C04C4 D200 23F9 226B 03AF9 0396B   413 ZLNZ     MVC   ZLAWD(1),ZLNOZONE   SET ZONING LAW = NO ZONING
0C04CA C7FE                         414          BR    14                  RETURN
0C04CC 92C0 23F9      C3AF9         415 ZLNQNPP  MVI   ZLAWD,X'00'         SET ZONING LAW = NO Q, NO PP
0C04EC C7FE                         416          BR    14                  RETURN
0C04E2 9203 23F9      03AF9         417 ZLQPP    MVI   ZLAWD,X'03'         SET ZONING LAW = Q, PP
0C04E6 07FE                         418          BR    14                  RETURN
0C04E8 9283 23F9      C3AF9         419 ZLQPPS   MVI   ZLAWD,X'83'         SET ZONING LAW = Q, PP SPECIAL
0C04EC C7FE                         420          BR    14                  RETURN
0C04EE 9201 23F9      03AF9         421 ZLNQPP   MVI   ZLAWD,X'01'         SET ZONING LAW = NO Q, PP
0C04F2 07FE                         422          BR    14                  RETURN
0C04F4 9281 23F9      03AF9         423 ZLNQPPS  MVI   ZLAWD,X'81'         SET ZONING LAW = NO Q, PP SPECIAL
0C04F8 C7FE                         424          BR    14                  RETURN
0C04FA 9202 23F9      C3AF9         425 ZLQNPP   MVI   ZLAWD,X'02'         SET ZONING LAW = Q, NO PP
0C04FE C7FE                         426          BR    14                  RETURN
0C05CC 9282 23F9      03AF9         427 ZLQNPPS  MVI   ZLAWD,X'82'         SET ZONING LAW = Q, NO PP SPECIAL
0C05C4 C7FE                         428          BR    14                  RETURN
                                    429          DROP  15
                                    430 *************************************************************
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                  F01AUG68   5/30/69

0C05C6                              432 SETQUAL  EQU   *                   (SET QUALITY)
0C0506                              433          USING *,15
0C05C6 96FC 23F4      C3AF4         434          OI    QCA,X'F0'           MAKE BLANK A 0
0C05CA 95F1 23F4      03AF4         435          CLI   QCA,X'F1'           IS QUALITY A
0C05CE 478C FC3A            00540   436          BE    QUALCAA
0C0512 95F2 23F4      C3AF4         437          CLI   QCA,X'F2'           IS QUALITY B
0C0516 4780 FC4C            00546   438          BE    QUALCAB
0C051A 95F3 23F4      C3AF4         439          CLI   QCA,X'F3'           IS QUALITY C
0C051E 478C F046            0054C   440          BE    QUALCAC
0C0522 95F4 23F4      C3AF4         441          CLI   QCA,X'F4'           IS QUALITY D
0C0526 478C F04C            00552   442          BE    QUALCAD
0C052A 95F5 23F4      C3AF4         443          CLI   QCA,X'F5'           IS QUALITY I3
0C052E 478C F052            00558   444          BE    QUALCAI3
0C0532 95F6 23F4      C3AF4         445          CLI   QCA,X'F6'           IS QUALITY I4
0C0536 478C F058            0055E   446          BE    QUALCAI4
0C053A 92CC 23F5      C3AF5         447          MVI   QCAD,B'11000000'    SET QUALITY = RUN OF BANK
0C053E C7FE                         448          BR    14
0C054C 92FF 23F5      C3AF5         449 QUALCAA  MVI   QCAD,B'11111111'    SET QUALITY = A
0C0544 C7FE                         450          BR    14
0C0546 92FE 23F5      C3AF5         451 QUALCAB  MVI   QCAD,B'11111110'    SET QUALITY = B
0C054A C7FE                         452          BR    14
0C054C 92FC 23F5      C3AF5         453 QUALCAC  MVI   QCAD,B'11111100'    SET QUALITY = C
0C055C C7FE                         454          BR    14
0C0552 92F8 23F5      03AF5         455 QUALCAD  MVI   QCAD,B'11111000'    SET QUALITY = D
0C0556 07FE                         456          BR    14
0C0558 92F0 23F5      03AF5         457 QUALCAI3 MVI   QCAD,B'11110000'    SET QUALITY = I3
0C055C 07FE                         458          BR    14
0C055E 92EC 23F5      03AF5         459 QUALCAI4 MVI   QCAD,B'11100000'    SET QUALITY = I4
0C0562 07FE                         460          BR    14
                                    461          DROP  15
                                    462 *******************************************************************
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                        F01AUG68  5/30/69

                                   464 *  THIS SUBROUTINE DETERMINES THE GEOMETRIC CENTER OF PROCESSED S&G,
                                   465 *  UNPROCESSED S&G, AND CRUSHED STONE (ALL WEIGHTED BY MATERIAL USAGE)
                                   466 *  OF FORECASTED DEVELOPMENTS SCHEDULED TO START WITHIN THE PLANNING
                                   467 *  HORIZON
                                   468 *  OUT PARAMETERS ARE WGCPSG (WEIGHTED GEOMETRIC CENTER PROCESSED S&G)
                                   469 *    WGCUPSG (WEIGHTED GEOMETRIC CENTER UNPROCESSED S&G), AND
                                   470 *    WGCCS (WEIGHTED GEOMETRIC CENTER CRUSHED STONE)
                                   471 *      BYTES 1&2=ROW, BYTES 3&4=COLUMN
0C0564                             472          USING *,3
0C0564                             473 SRWGC    EQU   *                         (SUBROUTINE WGC)
0C0564 90EC D00C            0000C  474          STM   14,12,12(13)
0C0568 183F                        475          LR    3,15
0C056A 58EC 3274            007D8  476          L     14,ASAVEWGC
0C056E 50ED CC08            00008  477          ST    14,8(13)
000572 50DE CC04            00004  478          ST    13,4(14)
0C0576 18DE                        479          LR    13,14
000578 58E0 2C6C            0376C  480          L     14,SDEVFOCH               LOAD REG14 WITH START DEVFO CHAIN
0C057C 12EE                        481          LTR   14,14                     WERE THERE ANY DEVFO'S
00057E 4740 316A            006CE  482          BM    WGCRET                    IF NOT, GO TO WGCRET
                                   483 *  AT THIS POINT THERE WAS AT LEAST 1 DEVFO
0C0582 1B88                        484          SR    8,8                       CLEAR REG8
0C0584 1B99                        485          SR    9,9                       CLEAR REG9
0C0586 1BAA                        486          SR    10,10                     CLEAR REG10
0C0588 50AC 3208            0076C  487          ST    10,RWPSG                  SET RWPSG = 0
0C058C 50AC 320C            00770  488          ST    10,CWPSG                  SET CWPSG = 0
0C059C 50AC 321C            00774  489          ST    10,WPSG                   SET WPSG = 0
0C0594 50AC 3214            00778  490          ST    10,RWUPSG                 SET RWUPSG = 0
0C0598 50A0 3218            0077C  491          ST    10,CWUPSG                 SET CWUPSG = 0
0C059C 50AC 321C            00780  492          ST    10,WUPSG                  SET WUPSG = 0
0C05AC 50A0 322C            00784  493          ST    10,RWCS                   SET RWCS = 0
0C05A4 50AC 3224            00788  494          ST    10,CWCS                   SET CWCS = 0
0C05A8 50AC 3228            0078C  495          ST    10,WCS                    SET WCS = 0
0C05AC 12EE                        496 WGCLOOP  LTR   14,14                     ARE WE DONE WITH ALL DEVFO'S
0C05AE 474C 3104            00668  497          BM    FIGWGC                    IF YES, GO TO FIGWGC
0C05B2 1BCC                        498          SR    12,12                     CLEAR REG12
0C05B4 43C0 EC1A            0C01A  499          IC    12,26(0,14)               INSERT YEAR DEVFO WILL START IN 12
0C05B8 1BBB                        500          SR    11,11                     CLEAR REG11
0C05BA 43BC 226A            0396A  501          IC    11,PLANHORZ               LOAD PLANNING HORIZON INTO REG11
0C05BE 1BCB                        502          SR    12,11                     SUBTRACT PLANNING HORIZON
0C05CC 43BC 2272            03972  503          IC    11,YEAR                   INSERT YEAR INTO REG11
0C05C4 1BCB                        504          SR    12,11                     SUBTRACT PRESENT YEAR
0C05C6 472C 30FC            00660  505          BP    UPWGC                     IF POSITIVE, DEVFO START IS BEYOND
                                   506 *                                        PLANNING HORIZON AND WILL NOT FIGURE
                                   507 *                                        INTO WGC
0C05CA 5880 3208            0076C  508          L     8,RWPSG                   LOAD REG8 WITH ACCUMULATED R*W
0C05CE 589C 320C            00770  509          L     9,CWPSG                   LOAD REG9 WITH ACCUMULATED C*W
0C05C2 58AC 321C            00774  510          L     10,WPSG                   LOAD REG10 WITH ACCUMULATED WT
0C05C6 1B44                        511          SR    4,4                       CLEAR REG4
0C05C8 1B66                        512          SR    6,6                       CLEAR REG6
0C05CA 485C ECCC            0CCC0  513          LH    5,0(0,14)                 LOAD ROW INTO REG5
0C05DE 487C ECC2            0C002  514          LH    7,2(0,14)                 LOAD COLUMN INTO REG7
0C05E2 58CC E01C            0C01C  515          L     12,28(0,14)               LOAD PROCESSED S&G INTO REG12
0C05E6 1C4C                        516          MR    4,12                      MULTIPLY ROW * WEIGHT
0C05E8 1C6C                        517          MR    6,12                      MULTIPLY COL * WEIGHT
0C05EA 1A85                        518          AR    8,5                       ACCUMULATE ROW * WEIGHT IN REG8
0C05EC 1A97                        519          AR    9,7                       ACCUMULATE COL * WT IN REG9
0C05EE 1AAC                        520          AR    10,12                     ACCUMULATE WEIGHT IN REG10
0C05FC 508C 3208            0076C  521          ST    8,RWPSG                   STORE IN ROW * WT PROC S&G
0C05F4 509C 32CC            00770  522          ST    9,CWPSG                   STORE IN COL * WT PROC S&G
0C05F8 50A0 3210            00774  523          ST    10,WPSG                   STORE IN WT PROC S&G
0C05FC 5880 3214            0C778  524          L     8,RWUPSG                  LOAD REG8 WITH S(ROW*WT)
0006C0 589C 3218            0077C  525          L     9,CWUPSG                  LOAD REG9 WITH S(COL*WT)
0C06C4 58AC 321C            00780  526          L     10,WUPSG                  LOAD REG10 WITH S(WEIGHT)
0C06C8 1B44                        527          SR    4,4                       CLEAR REG4
0C06CA 1B66                        528          SR    6,6                       CLEAR REG6
0C06CC 485C ECC0            0C000  529          LH    5,0(0,14)                 LOAD ROW INTO REG5
0C061C 4870 ECC2            0C002  530          LH    7,2(0,14)                 LOAD COLUMN INTO REG7
0C0614 58CC EC20            0C020  531          L     12,32(0,14)               LOAD UNPROCESSED S&G INTO REG12
0C0618 1C4C                        532          MR    4,12                      MULTIPLY ROW * WEIGHT
0C061A 1C6C                        533          MR    6,12                      MULTIPLY COL * WEIGHT
0C061C 1A85                        534          AR    8,5                       ACCUMULATE ROW * WEIGHT IN REG8
0C061E 1A97                        535          AR    9,7                       ACCUMULATE COL * WT IN REG9
0C062C 1AAC                        536          AR    10,12                     ACCUMULATE WEIGHT IN REG10
0C0622 5080 3214            00778  537          ST    8,RWUPSG                  STORE IN ROW*WT UNPROC S&G
0C0626 509C 3218            0077C  538          ST    9,CWUPSG                  STORE IN COL*WT UNPROC S&G
0C062A 50AC 321C            00780  539          ST    10,WUPSG                  STORE IN WEIGHT UNPROC S&G
0C062E 5880 322C            00784  540          L     8,RWCS                    LOAD REG8 WITH S(ROW*WT)
000632 5890 3224            0C788  541          L     9,CWCS                    LOAD REG9 WITH S(COL*WT)
0C0636 58AC 3228            0078C  542          L     10,WCS                    LOAD REG10 WITH S(WEIGHT)
0C063A 1B44                        543          SR    4,4                       CLEAR REG4
0C063C 1B66                        544          SR    6,6                       CLEAR REG6
00063E 485C ECCC            0C000  545          LH    5,0(0,14)                 LOAD ROW INTO REG5
000642 4870 ECC2            00002  546          LH    7,2(0,14)                 LOAD COLUMN INTO REG7
000646 58CC E024            0C024  547          L     12,36(0,14)               LOAD CRUSHED STONE INTO REG12
0C064A 1C4C                        548          MR    4,12                      MULTIPLY ROW * WEIGHT
0C064C 1C6C                        549          MR    6,12                      MULTIPLY COL * WEIGHT
0C064E 1A85                        550          AR    8,5                       ACCUMULATE ROW*WT IN REG8
0C065C 1A97                        551          AR    9,7                       ACCUMULATE COL * WT IN REG9
000652 1AAC                        552          AR    10,12                     ACCUMULATE WEIGHT IN REG10
0C0654 5080 322C            00784  553          ST    8,RWCS                    STORE IN ROW*WT CRUSHED STONE
0C0658 5090 3224            00788  554          ST    9,CWCS                    STORE IN COL*WT CRUSHED STONE
0C065C 50A0 3228            0078C  555          ST    10,WCS                    STORE IN WEIGHT CRUSHED STONE
0006EC 58EC E038            0C038  556 UPWGC    L     14,56(0,14)               LOAD NEXT DEVFO INTO REG14
0C0664 47FC 3048            005AC  557          B     WGCLOOP                   GO TO WGCLOOP
                                   558 *  AT THIS POINT WE MUST FIGURE WEIGHTED GEOMETRIC CENTER(S)
0C0668                             559 FIGWGC   EQU   *                         (FIGURE WEIGHTED GEOM CENTER)
0C0668 58AC 321C            00774  560          L     10,WPSG                   LOAD S(WT) INTO REG10
0C066C 12AA                        561          LTR   10,10                     WERE THERE ANY
0C066E 478C 3126            0068A  562          BZ    PSGSAPY                   IF NOT, GO TO PSG SAME AS PREV YR
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                          F01AUG68   5/30/69

000672 1844                         563          SR    4,4                 CLEAR REG4
000674 585C 3208            0076C   564          L     5,RWPSG             LOAD S(R*W) INTO REG5
0C0678 1D4A                         565          DR    4,10                DIVIDE BY S(WT)
0C067A 4050 20B8            03788   566          STH   5,WGCPSG            STORE ROW WGC
00067E 1844                         567          SR    4,4                 CLEAR REG4
0C0680 585C 320C            00770   568          L     5,CWPSG             LOAD REG5 WITH S(COL*WT)
8C0684 1D4A                         569          DR    4,10                DIVIDE BY S(WT)
0C0686 4050 20BA            0378A   570          STH   5,WGCPSG+2          STORE WGC COL
0C068A 58A0 321C            00780   571 PSGSAPY  L     10,WUPSG            LOAD REG10 WITH S(WT) UNPROC S&G
0C068E 12AA                         572          LTR   10,10               WERE THERE ANY
00069C 478C 3148            006AC   573          BZ    UPSGSAPY            IF NOT GO TO UPSGSAPY
0C0694 1844                         574          SR    4,4                 CLEAR REG4
0C0696 5850 3214            00778   575          L     5,RWUPSG            LOAD S(ROW*WT) INTO REG5
0C069A 1D4A                         576          DR    4,10                DIVIDE BY S(WT)
0C069C 4050 20BC            0378C   577          STH   5,WGCUPSG           STORE ROW WGC
0C06AC 1844                         578          SR    4,4                 CLEAR REG4
0C06A2 585C 3218            0077C   579          L     5,CWUPSG            LOAD REG5 WITH S(COL*WT)
0006A6 1D4A                         580          DR    4,10                DIVIDE BY S(WT)
0006A8 4C50 20BE            0378E   581          STH   5,WGCUPSG+2         STORE COL WGC
0C06AC 58A0 3228            0078C   582 UPSGSAPY L     10,WCS              LOAD REG10 WITH S(WT) CRUSHED STONE
0C06BC 12AA                         583          LTR   10,10               WERE THERE ANY
0006B2 4780 316A            006CE   584          BZ    WGCRET              IF NOT, GO TO WGCRET
0C06B6 1844                         585          SR    4,4                 CLEAR REG 4
0C06B8 585C 322C            00784   586          L     5,RWCS              LOAD REG5 WITH S(ROW*WT)
0C06BC 1D4A                         587          DR    4,10                DIVIDE BY SUM(WT)
0C06BE 4050 2CCC            037C0   588          STH   5,WGCCS             STORE ROW WGC
0CC6C2 1844                         589          SR    4,4                 CLEAR REG4
0C06C4 5850 3224            00788   590          L     5,CWCS              LOAD REG5 WITH S(COL*WT)
0C06C8 1D4A                         591          DR    4,10                DIVIDE BY S(WT)
0C06CA 4050 20C2            037C2   592          STH   5,WGCCS+2           STORE COL WGC
0C06CE                              593 WGCRET   EQU   *                   (WGC RETURN)
0C06CE 9209 22C8      039C8         594          MVI   CARCONT,X'09'       SET CARRIAGE CONTROL
0006D2 C22F 22DD 3278 C39DD 007DC   595          MVC   OUTLINE+20(L'M38),M38
0C06D8 D218 230E 32A8 03A0E 0080C   596          MVC   OUTLINE+69(L'M39),M39
0C06DE 48BC 2088            03788   597          LH    11,WGCPSG           ''
0C06E2 4EB0 2C0C            037C0   598          CVD   11,DW               ''
0C06E6 DE03 22E2 2CC6 039E2 037C6   599          ED    OUTLINE+25(4),DW+6  ''
0CC6EC 48B0 2CBA            037BA   600          LH    11,WGCPSG+2         ''
0C06FC 4EBC 2C00            03700   601          CVD   11,DW               ''
0C06F4 DE03 22E8 2CC6 039E8 037C6   602          ED    OUTLINE+31(4),DW+6  ''
0006FA 58F0 204C            0374C   603          L     15,ALINEOUT         ''
0C06FE 05EF                         604          BALR  14,15               ''
0C07CC D22F 22DD 3278 039DD 007DC   605          MVC   OUTLINE+20(L'M38),M38
0C07C6 D21A 230E 32C1 03A0E 00825   606          MVC   OUTLINE+69(L'M40),M40
0C07CC 48BC 2CBC            037BC   607          LH    11,WGCUPSG
0C071C 4EBC 2CC0            03700   608          CVD   11,DW               ''
0C0714 DE03 22E2 2CC6 039E2 037C6   609          ED    OUTLINE+25(4),DW+6  ''
0C071A 48BC 2CBE            037BE   610          LH    11,WGCUPSG+2
0C071E 4EB0 2CC0            03700   611          CVD   11,DW               ''
0C0722 DE03 22E8 2CC6 039E8 037C6   612          ED    OUTLINE+31(4),DW+6  ''
0C0728 58FC 204C            0374C   613          L     15,ALINEOUT         ''
0C072C C5EF                         614          BALR  14,15               ''
0C072E 9219 22C8      039C8         615          MVI   CARCONT,X'19'       SKIP 3 LINES AFTER PRINTING
0C0732 D22F 22DD 3278 039DD 007DC   616          MVC   OUTLINE+20(L'M38),M38
0C0738 D20C 230E 32DC C3A0E 00840   617          MVC   OUTLINE+69(L'M41),M41
0C073E 48B0 2CC0            037C0   618          LH    11,WGCCS
0C0742 4EB0 2CCC            037C0   619          CVD   11,DW
0C0746 DE03 22E2 2C06 039E2 03706   620          ED    OUTLINE+25(4),DW+6  ''
0C074C 48BC 2CC2            037C2   621          LH    11,WGCCS+2
0C075C 4EB0 2C0C            03700   622          CVD   11,DW               ''
0C0754 DE03 22E8 2CC6 C39E8 03706   623          ED    OUTLINE+31(4),DW+6  ''
0C075A 58FC 204C            0374C   624          L     15,ALINEOUT         ''
0C075E 05EF                         625          BALR  14,15               ''
0C076C 58DC 3230            00794   626          L     13,SAVEWGC+4
0C0764 98EC DC0C            0CCCC   627          LM    14,12,12(13)
0C0768 07FE                         628          BR    14                  RETURN
0C076C                              629 RWPSG    DS    F
0C077C                              630 CWPSG    DS    F
0C0774                              631 WPSG     DS    F
0C0778                              632 RWUPSG   DS    F
0C077C                              633 CWUPSG   DS    F
0C0780                              634 WUPSG    DS    F
0C0784                              635 RWCS     DS    F
0C0788                              636 CWCS     DS    F
0C078C                              637 WCS      DS    F
0C0790                              638 SAVEWGC  DS    18F
0C07D8 0CC00790                     639 ASAVEWGC DC    A(SAVEWGC)
0C07DC C7D9C9C440402020             640 M38      DC    C'GRID  --/,  -/- IS WEIGHTED GEOMETRIC CENTER FOR'
0C08CC D7D9D6C3C5E2E2C5             641 M39      DC    C'PROCESSED SAND AND GRAVEL'
000825 E4D5D7D9D6C3C5E2             642 M40      DC    C'UNPROCESSED SAND AND GRAVEL'
0C084C C3D9E4E2C8C5C440             643 M41      DC    C'CRUSHED STONE'
0C085C                              644          LTORG
                                    645          DROP  3
                                    646 *****************************************************************
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                             F01AUG68   5/30/69

000850                             648             USING *,3
                                   649 *  THIS SUBROUTINE READS A CARD AND PLACES IT INTO AN AREA CALLED INPUT
000850 90EC D00C            0000C  650 CARDIN   STM   14,12,12(13)        (CARD INPUT ROUTINE)
000854 183F                        651            LR    3,15
000856 41E0 302C            0087C  652            LA    14,ISAVE
00085A 50ED D008            00008  653            ST    14,8(13)
00085E 50DE D004            00004  654            ST    13,4(14)
000862 18DE                        655            LR    13,14
                                   656            GET   INDCB,INPUT
000864 4110 3074            008C4  657+           LA    1,INDCB LOAD PARAMETER REG 1
000868 4100 2277            03977  658+           LA    0,INPUT LOAD PARAMETER REG 0
00086C 58F0 1030            00030  659+           L     15,48(0,1) LOAD GET ROUTINE ADDR.
000870 05EF                        660+           BALR  14,15 LINK TO GET ROUTINE
000872 58D0 3030            00880  661            L     13,ISAVE+4
000876 98EC D00C            0000C  662            LM    14,12,12(13)
00087A 07FE                        663            BR    14
00087C                             664 ISAVE    DS    18F
                                   665            PRINT NOGEN
                                   666 INDCB    DCB   MACRF=GM,DSORG=PS,DDNAME=SYSIN
                                   667                  *,***  IHB063  DDNAME SHORT-PADDED TO 8 CHAR
                                   723            PRINT GEN
                                   724            DROP  3


                                   726 *  THIS SUBROUTINE WRITES OUTPUT FROM AN AREA CALLED OUTLINE
000924                             727            USING *,3
000924 90EC D00C            0000C  728 LINEOUT  STM   14,12,12(13)        (OUTPUT ROUTINE)
000928 183F                        729            LR    3,15
00092A 41E0 3038            0095C  730            LA    14,OSAVE
00092E 50ED D008            00008  731            ST    14,8(13)
000932 50DE D004            00004  732            ST    13,4(14)
000936 18DE                        733            LR    13,14
                                   734            PUT   OUTDCB,CARCONT
000938 4110 3080            009A4  735+           LA    1,OUTDCB LOAD PARAMETER REG 1
00093C 4100 22C8            039C8  736+           LA    0,CARCONT LOAD PARAMETER REG 0
000940 58F0 1030            00030  737+           L     15,48(0,1) LOAD PUT ROUTINE ADDR.
000944 05EF                        738+           BALR  14,15 LINK TO PUT ROUTINE
000946 9240 22C9      039C9        739            MVI   OUTLINE,C' '        CLEAR OUTPUT LINE
00094A D282 22CA 22C9 039CA 039C9  740            MVC   OUTLINE+1(131),OUTLINE
000950 58D0 303C            00960  741            L     13,OSAVE+4
000954 98EC D00C            0000C  742            LM    14,12,12(13)
000958 07FE                        743            BR    14
00095C                             744 OSAVE    DS    18F
                                   745            PRINT NOGEN
                                   746 OUTDCB   DCB   MACRF=PM,DSORG=PS,DDNAME=SYSOUT,                           X
                                                        LRECL=133,RECFM=FBM,BLKSIZE=3591
                                   747                  *,***  IHB063  DDNAME SHORT-PADDED TO 8 CHAR
                                   803            PRINT GEN
000AC8                             804            LTORG
                                   805            DROP  3
                                   806 ******************************************************************
```

```
  LCC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                              F01AUG68   5/30/69

0C0A08                             808          USING *,3
0CCAC8                             809 SRPPU    EQU   *
0CCAC8 90BC D0CC             0C00C 810          STM   14,12,12(13)
0CCACC 183F                        811          LR    3,15
0C0ACE 58E0 3068             00A70 812          L     14,ASAVPPU
0C0A12 50ED 0008             0C008 813          ST    14,8(13)
0C0A16 50DE 0C04             0C004 814          ST    13,4(14)
0C0A1A 18DE                        815          LR    13,14
0C0A1C 5840 2118             03818 816          L     4,WIPBE          LOAD REG4 WITH WIP BEING ESTABLISHED
0C0A2C 1855                        817          SR    5,5              CLEAR REG5
0C0A22 4350 401B             0001B 818          IC    5,27(0,4)        INSET YEARS TO COMPLETION INTO REG5
0C0A26 1866                        819          SR    6,6              CLEAR REG6
0C0A28 5870 402C             0C020 820          L     7,32(0,4)        LOAD UNPROCESSED S&G TO COMPLETION
                                   821 *                               INTO REG7
0C0A2C 1D65                        822          DR    6,5              DIVIDE LIFE BY YRS TO COMPLETION
0C0A2E 5070 212C             0382C 823          ST    7,PPUUPSG        STORE PRESENT USAGE UNPROCESSED S&G
0C0A32 1866                        824          SR    6,6              CLEAR REG6
0C0A34 5870 4C24             0C024 825          L     7,36(0,4)        LOAD CS TO COMPLETION INTO REG7
0C0A38 1D65                        826          DR    6,5              DIVIDE CS BY YEARS TO COMPLETION
0C0A3A 5070 213C             03830 827          ST    7,PPUCS          STORE PRESENT USAGE CS
0C0A3E 1866                        828          SR    6,6              CLEAR REG6
0C0A4C 587C 401C             0001C 829          L     7,28(0,4)        LOAD PROCESSED S&G TO COMPLETION
0C0A44 1D65                        830          DR    6,5              DIVIDE BY YRS TO COMPLETION
0C0A48 507C 2128             03828 831          ST    7,PPUPSG         STORE PRESENT USAGE PROCESSED S&G
0C0A4A 1855                        832          SR    5,5              CLEAR REG5
0C0A4C 4350 4029             0C029 833          IC    5,41(0,4)        INSERT PERCENT SAND TO COMPLETION
0CCA5C 1C65                        834          MR    6,5              MULT PSG USAGE BY PERCENT SAND
0C0A52 5D60 214C             03840 835          D     6,HUNDRED        AND DIVIDE BY 100 = SAND USAGE
0C0A56 507C 2134             03834 836          ST    7,PPUSAND        STORE SAND USAGE
0C0A5A 5870 2128             03828 837          L     7,PPUPSG         LOAD REG7 WITH PRESENT USAGE S&G
0C0A5E 5B7C 2134             03834 838          S     7,PPUSAND        SUBTRACT SAND
0C0A62 507C 2138             03838 839          ST    7,PPUGRAVL       STORE PRESENT USAGE GRAVEL
0C0A66 58DC 307C             0CA78 840          L     13,SAVPPU+4
0C0A6A 98EC DCCC             0C00C 841          LM    14,12,12(13)
0C0A6E C7FE                        842          BR    14
0C0A7C C0CC0A74                    843 ASAVPPU  DC    A(SAVPPU)
0CCA74                             844 SAVPPU   DS    18F
0CCACC                             845          LTORG
                                   846 ************************************************************************
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                              F01AUG68   5/30/69

0C0ACC                              848 BEGINIT  CSECT
000ACC                              849          USING *,12
0C0ACC 18CF                         850          LR    12,15                LOAD BASE REG12
0C37CC                              851          USING COMMON,2
0C0AC2 9288 22C8       039C8        852          MVI   CARCONT,X'88'        SKIP TO TOP OF PAGE
0C0AC6 58FC 204C             0374C  853          L     15,ALINEOUT          ''
0C0ACA C5EF                         854          BALR  14,15                ''
0C0ACC 58FC 204C             0374C  855          L     15,ALINEOUT          WRITE HEADING
0C0ADC 9211 22C8       039C8        856          MVI   CARCONT,X'11'        ''
0C0AD4 D20C 22F1 2545 039F1 03C45   857          MVC   OUTLINE+40(L'BYM),BYM   ''
0C0ADA 1877                         858          SR    7,7                  ''
0C0ADC 4370 2272             03972  859          IC    7,YEAR               ''
0C0AEC 4E70 2C00             03700  860          CVD   7,DW
0C0AE4 DE03 22FB 2CC6 039FB 03706   861          ED    OUTLINE+50(4),DW+6
0C0AEA 05EF                         862          BALR  14,15                ''
0C0AEC 9209 22C8       039C8        863          MVI   CARCONT,X'09'        ''
0C0AFC D232 22DD C914 039DD 01304   864          MVC   OUTLINE+20(L'H1),H1    ''
0C0AF6 05EF                         865          BALR  14,15
0C0AF8 9219 22C8       039C8        866          MVI   CARCONT,X'19'        ''
0C0AFC D233 22DD C947 039DD 01407   867          MVC   OUTLINE+20(L'H2),H2   ''
0C0BC2 05EF                         868          BALR  14,15                ''
0C0B04 58FC 2C3C             0373C  869          L     15,ASRWGC            LOAD 15 WITH ADDR SR WGC
0C0B08 05EF                         870          BALR  14,15                CALL SUBRTNE WEIGHTED GEOM CENTER
0C0BCA 5870 2C0C             0370C  871          L     7,AOSQ               LOAD REG7 WITH ADDR OUTSIDE Q'S
0C0BCE D5C1 7C0C 2C60 C0000 03760   872 TESTOUTS CLC   0(2,7),MINONE        ARE WE DONE WITH OUTSIDE Q'S
0C0B14 4780 C066             00B26  873          BE    SETACCS              IF YES GO TO SETACCS
0C0B18 D203 7C0C C98C C000C 01440   874          MVC   12(4,7),=F'0'        SET PRESENT MATL USED = 0
0C0B1E 4170 701C             00010  875          LA    7,16(0,7)            POINT REG7 AT NEXT OUTSIDE Q
0C0B22 47FC C04E             00B0E  876          B     TESTOUTS             GO TO TESTOUTS
0C0B26                              877 SETACCS  EQU   *                    (SET ACCUMULATORS)
0C0B26 1877                         878          SR    7,7                  CLEAR REG7
0C0B28 507C 214C             0384C  879          ST    7,MWTD               SET MWTD = 0
0C0B2C 5070 215C             03850  880          ST    7,MWTDPQ             SET MWTDPQ = 0
0C0B3C 5070 2148             03848  881          ST    7,FQADY              SET FQADY = 0
0C0B34 5070 211C             0381C  882          ST    7,TYPQASG
0C0B38 5C70 212C             03820  883          ST    7,TYPQAUSG
0C0B3C 5070 2124             03824  884          ST    7,TYPQACS
                                    885 *  THIS SECTION SETS THE ZONED OUT BIT FOR ALL Q'S AND PQ'S WHICH
                                    886 *  HAVE BEEN ZONED OUT DURING THE PREVIOUS PERIOD
0C0B4C 589C 2C64             03764  887           L     9,SQCH              LOAD REG9 WITH START Q CHAIN
0C0B44 1299                         888 TQFZO     LTR   9,9                 ARE WE DONE WITH ALL Q'S
0C0B46 4740 C0A4             00B64  889           BM    TPQFZO              IF YES, GO TO TPQFZO
0C0B4A D203 904C C98C C004C 01440   890          MVC   76(4,9),=F'0'        SET USAGE DURING PERIOD = 0
0C0B5C 9103 9C04       C00C4        891          TM    4(9),X'03'           HAS Q(9) BEEN ZONED OUT
0C0B54 471C C09C             00B5C  892          BO    CNQFZO               IF NOT GO TO CNQFZO
0C0B58 9680 9C05       C0005        893           OI    5(9),X'80'          SET Q ZONED OUT BIT =1
0C0B5C 5890 9C34             00034  894 CNQFZO    L     9,52(0,9)           LOAD REG9 WITH NEXT Q IN CHAIN
0C0B6C 47FC C084             00B44  895          B     TQFZO                GO TO TQFZO
0C0B64 589C 2C68             03768  896 TPQFZO   L     9,SPQCH              LOAD REG9 WITH START PQ CHAIN
0C0B68 1299                         897 TNPQFZO   LTR   9,9                 ARE WE DONE WITH ALL PQ'S
0C0B6A 474C C0EC             00BAC  898          BM    TESTQS               IF YES GO TO TESTQS
0C0B6E D203 904C C98C C004C 01440   899          MVC   76(4,9),=F'0'        SET PQ MATL USED = 0
0C0B74 918C 9C06       C0006        900          TM    6(9),X'80'           HAS PQ(9) BEEN PREVIOUSLY ZONED OUT
0C0B78 47EC C0CC             00B8C  901          BNO   HIBZODPY             IF NOT, GO TO HIBZODPY
0C0B7C 9102 9004       C00C4        902          TM    4(9),X'02'           CAN IT AGAIN BE USED
0C0B8C 47EC C0E4             00BA4  903          BNO   CNPQFZO              IF NOT, GO TO CNPQFZO
0C0B84 947F 9C06       C0006        904          NI    6(9),X'7F'           UN ZONE OUT PQ(9)
0C0B88 47FC C0E4             00BA4  905          B     CNPQFZO              GO TO CNPQFZO
0C0B8C                              906 HIBZODPY EQU   *        (HAS IT BEEN ZONED OUT DURING PREVIOUS YEAR)
0C0B8C 9102 9C04       C0004        907          TM    4(9),X'02'           HAS PQ(9) BEEN ZONED OUT
0C0B90 4710 C0E4             00BA4  908           BO    CNPQFZO             IF NOT GO TO CNPQFZO
0C0B94 968C 9C06       C0006        909           OI    6(9),X'80'          SET PQ(9) ZONED OUT BIT =1
000B98 5880 215C             03850  910          L     8,MWTDPQ             LOAD MATL WASTED IN PQ INTO REG8
0C0B9C 5A8C 9C08             0C008  911          A     8,8(0,9)             ADD MATL WASTED AT PQ(9)
0C0BAC 5080 215C             03850  912          ST    8,MWTDPQ             UPDATE MATERIAL WASTED AT PQ
0C0BA4 5890 9034             0C034  913 CNPQFZO   L     9,52(0,9)           LOAD REG9 WITH ADDR NEXT PQ IN CHAIN
0C0BA8 47F0 CCA8             00B68  914          B     TNPQFZO              GO TO TNPQFZO
0C0BAC                              915 TESTQS    EQU   *
0C0BAC 5840 2C64             03764  916          L     4,SQCH               LOAD 4 WITH START QUARRY CHAIN
0C0B8C 1244                         917 ZNOUTDLP LTR   4,4                  IS ADDRESS NEGATICE .. ARE WE DONE
                                    918 *                                   WITH SELF-PRESERVATION MODEL
0C0B82 4780 C0FC             00BBC  919          BNM   NDWSPM               IF NOT DONE, GO TO NDWSPM
0C0B86 58F0 2054             03754  920          L     15,AMINEDP           OTHERWISE GO TO MINEDP
000B8A 07FF                         921          BR    15                   ''
0C0B8C 914C 4CC5       000C5        922 NDWSPM   TM    5(4),X'40'           IS IT A S&G QUARRY
0C0BCC 4780 C3E0             00EA0  923          BZ    IWACSQ               IF NOT GO TO IT WAS A CS QUARRY
0C0BC4 9180 4CC5       CC005        924          TM    5(4),X'80'           HAS Q BEEN ZONED OUT
0C0BC8 4710 C11E             00BDE  925          BO    QWASZO               IF SO, GO TO Q WAS ZONED OUT
                                    926 *  AT THIS POINT Q WAS NOT ZONED OUT. WE WILL TEST IT FOR DEPLETION
0C0BCC 585C 4008             0C008  927          L     5,8(0,4)             LOAD LIFE OF Q INTO REG 5
0C0BCC 1255                         928          LTR   5,5                  TEST LIFE
0C0BD2 47D0 C12A             00BEA  929          BNP   QWASDP               IF LIFE NOT +, GO TO QWASDP
                                    930 *  AT THIS POINT, Q WAS NOT DEPLETED OR ZONED OUT
0C0BD6 5840 4C34             00034  931 UPDTR4   L     4,52(0,4)            LOAD ADDR OF NEXT Q INTO REG 4
0C0BCA 47F0 C0F0             00BB0  932          B     ZNOUTDLP             GO TO ZONE OUT DEPLETION LOOP
                                    933 *  AT THIS POINT REG 4 CONTAINS ADDR OF Q WHICH IS TO BE ZONED OUT
0C0BDE                              934 QWASZO   EQU   *                    (QUARRY WAS ZONED OUT)
0C0BDE 9101 4CC5       C0005        935          TM    5(4),X'01'           IS Q A PROCESSING PLANT
000BE2 4710 C1B4             00C74  936          BO    DETALOW              IF YES, GO TO DETALOW
0C0BE6 47FC C12E             0C8EE  937          B     SETALZ               GO TO SETALZ
0C0BEA                              938 QWASDP   EQU   *                    (QUARRY WAS DEPLETED)
0C0BEA 94FD 4005       C0005        939          NI    5(4),B'11111101'     SET ACTIVE Q INDICATOR TO 0
0C0BEE 1B66                         940 SETALZ   SR    6,6                  SET REG6 TO 0
0C0BFC 5060 2CCC             037CC  941          ST    6,AOEPP              SET ALLOWANCE TO 0
0C0BF4 47F0 C1BE             00C7E  942          B     ARETMQ               GO TO ARETMQ
                                    943 *  AT THIS POINT, QUARRY IN REG 4 MUST BE DELETED
0C0BF8                              944 ZONOUTQ4 EQU    *                   (REMOVE Q(4) FROM SYSTEM)
0C0BF8 5850 4034             00034  945            L     5,52(0,4)          LOAD REG5 WITH NEXT Q IN CHAIN
0C0BFC 5040 2C94             03794  946          ST    4,AQTBD              STORE ADDR OF Q TO BE DELETED
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                     F01AUG68  5/30/69

0C0CCC 58F0 2024            03724   947          L     15,ASRDQ               DELETE IT (CALL SUBROUTINE DELETE Q)
0C0CC4 05EF                         948          BALR  14,15                  ''
0C0CC6 94FC 4C05      C0005         949          NI    5(4),X'FC'             SET Q AND PP INDICATOR TO 00
0C0C0A 58B0 4008            00008   950          L     11,8(0,4)              LOAD REG11 WITH REMAINING LIFE Q(4)
0C0CCE 12BB                         951          LTR   11,11                  IS LIFE 0 OR NEGATIVE
0C0C1C 47DC C15C            00C1C   952          BNP   DACCMW1                IF YES, GO TO DACCMW1
0C0C14 5AB0 214C            0384C   953          A     11,MWTD                OTHERWISE ADD TO MATERIAL WASTED
                                    954 *                                     TO DATE
0C0C18 50B0 214C            0384C   955          ST    11,MWTD                UPDATE MATERIAL WASTED TO DATE
0C0C1C                              956 DACCMW1  EQU   *
0C0C1C 9209 22C8      039C8         957          MVI   CARCONT,X'09'          SET CARRIAGE CONTROL
0C0C2C D236 22DD 2408 C39DD 038C8   958          MVC   OUTLINE+20(L'M35),M35 MOVE MESSAGE TO OUTPUT LINE
0C0C26 48B4 CCCC            0C000   959          LH    11,0(4)                MOVE ROW TO REG11
0C0C2A 4EBC 2C00            03700   960          CVD   11,DW                  CONVERT ROW TO DECIMAL
0C0C2E DE03 22EC 2C06 C39EC 037C6   961          ED    OUTLINE+35(4),DW+6     EDIT ROW
0C0C34 48B4 CCC2            0CCC2   962          LH    11,2(4)                LOAD REG11 WITH COLUMN
0C0C38 4EBC 2CCC            03700   963          CVD   11,DW                  CONVERT COLUMN TO DECIMAL
0C0C3C DE03 22F2 2C06 C39F2 037C6   964          ED    OUTLINE+41(4),DW+6     EDIT COLUMN
0CCC42 58FC 2C4C            0374C   965          L     15,ALINEOUT            CALL OUTPUT ROUTINE
0C0C46 05FF                         966          BALR  14,15                  ''
0C0C48 9219 22C8      C39C8         967          MVI   CARCONT,X'19'
0C0C4C D222 22CD 243F 039DD 0383F   968          MVC   OUTLINE+20(L'M36),M36  MOVE MESSAGE TO OUTPUT FIELD
0C0C52 58BC 4CC8            0C008   969          L     11,8(0,4)              MOVE LIFE OF Q(4) TO REG11
0C0C56 12B8                         970          LTR   11,11                  IS LIFE POSITIVE
0C0C58 472C C19E            00C5E   971          BP    EDLIFE                 IF YES GO TO EDLIFE
0C0C5C 1BB8                         972          SR    11,11                  OTHERWISE SET LIFE TO 0
0C0C5E 4EBC 2CCC            037C0   973 EDLIFE   CVD   11,DW                  CONVERT LIFE TO DECIMAL
0C0C62 CE09 22F0 2C04 C39F0 037C4   974          ED    OUTLINE+39(10),DW+4     EDIT LIFE
0C0C68 58FC 2C4C            0374C   975          L     15,ALINEOUT            CALL OUTPUT ROUTINE
0C0C6C C5EF                         976          BALR  14,15                  ''
0C0C6E 1845                         977          LR     4,5                   LOAD ADDR OF NEXT Q IN CHAIN INTO 5
0C0C7C 47FC CCFC            0C880   978          B     ZNOUTDLP               GO TO ZNOUTDLP
0C0C74 5040 2CDC            037D0   979 DETALOW  ST    4,APPTBM               STORE ADDR IN APPTBM
0CCC78 58FC 2C4C            03740   980          L     15,ASRADEPP            CALL SUBRTNE DETERMINE ALLOWANCE
0C0C7C 05EF                         981          BALR  14,15                  ''
0CCC7E                              982 ARETMQ   EQU   *                      (ARE THERE ANY MORE QUARRIES)
0C0C7E 589C 2C64            03764   983          L     9,SQCH                 LOAD 9 WITH START QUARRY CHAIN
0C0C82 1299                         984 LFAQ     LTR   9,9                    IS ADDR NEG (ARE WE DONE)
0C0C84 474C C1F4            0CCB4   985          BM    OHNOQ                  IF SO, GO TO OWNER HAS NO OTHER Q'S
0C0C88 1949                         986          CR    4,9                    IS Q(9) SAME Q AS Q(4)
0CCC8A 478C C1EC            00CAC   987          BE    UPDTPTR9               IF YES GO TO UPDTPTR9
0C0C8E D5CC 4C07 9CC7 CC0C7 0C007   988          CLC   7(1,4),7(9)            IS IT OWNED BY SAME OWNER
0C0C94 477C C1EC            00CAC   989          BNE   UPDTPTR9               IF NOT, GO TO UPDATE PTR 9
0C0C98 918C 9C05      CC0C5         990          TM    5(9),X'80'             HAS IT BEEN ZONED OUT
0C0C9C 471C C1EC            00CAC   991          BO    UPDTPTR9               IF YES GO TO UPDTPTR9
                                    992 *  AT THIS POINT IT IS A S&G Q OWNED BY SAME OWNER.  WE WILL NOW
                                    993 *   SEE IF ITS LIFE IS GREATER THAN 1 YEAR **************
0C0CAC 58BC 9C08            0C008   994          L     11,8(0,9)              LOAD LIFE Q(9) INTO REG11
0C0CA4 59BC 9CCC            0C00C   995          C     11,12(0,9)             COMPARE REMAINING LIFE WITH MAXIMUM
                                    996 *                                     YEARLY OUTPUT
0C0CA8 472C C558            01018   997          BH    OHAQ                   IF LIFE GREATER THAN 1 YR GOTO OHAQ
0C0CAC 589C 9C34            00034   998 UPDTPTR9 L     9,52(0,9)              LOAD ADDR OF NEXT Q INTO REG 9
0C0CBC 47FC C1C2            0CC82   999          B     LFAQ                   GO TO LOOK FOR ANOTHER QUARRY
0C0CB4                             1000 OHNOQ    EQU   *                      (OWNER HAS NO OTHER QUARRIES)
0C0CB4 9108 4CC5      CC005        1001          TM    5(4),X'08'             DOES OWNER WISH TO SELF-PRESERVE
0C0CB8 47E0 C138            00BF8  1002          BNO   ZONOUTQ4               IF NOT, GO TO ZONOUTQ4
0C0CBC 9101 4CC5      CC0C5        1003          TM    5(4),X'01'             WAS Q(4) A PROCESSING PLANT
0C0CCC 478C C362            00E22  1004          BZ    Q4NPP                  IF NOT GO TO Q4NPP
0C0CC4 9101 4CC4      CC0C4        1005          TM    4(4),X'01'             CAN PROCESSING CONTINUE
0C0CC8 478C C2FC            0CDB0  1006          BZ    Q4PCNC                 IF NOT GO TO Q4PCNC
                                   1007 *  AT THIS POINT Q(4) IS A PROCESSING PLANT AND PROCESSING CAN CONTINUE
0C0CCC 9203 23F0      C3AF0        1008          MVI   STRATEGY,X'03'         SET STRATEGY BYTE
0C0CDC 5040 21CC            03800  1009          ST    4,0IQ                  STORE ADDR Q(4) IN QIQ
0C0CD4 58FC 2C44            03744  1010          L     15,ASRPQCST            CALL SRPQCOST
0C0CD8 05EF                        1011          BALR  14,15                  ''
0C0CDA 9501 23F1      C3AF1        1012          CLI   PTPQF,X'01'            WERE ANY PROCESSING PQ'S FOUND
0C0CDE 4770 C37C            00E30  1013          BNE   WANPTF                 IF NOT, GO TO WANPTF
0C0CE2 D5C3 21C4 2108 C38C4 03808  1014          CLC   COSTCMP1(4),COSTCMP2  COMPARE COST USING PP AT SITE WITH
                                   1015 *                                      COST USING Q(4) AS AN INTER PT
0CCCE8 474C C306            0CDC6  1016          BL    EOWPP                  IF COST IS LOWER WITH PP AT SITE,
                                   1017 *                                     GO TOEQWPP
                                   1018 *  AT THIS POINT, PQ WHOSE ACDR IS IN ADDRPQ2 MUST BE ESTABLISHED
0C0CEC D201 402E 20EC C002E 037EC  1019          MVC   46(2,4),AMORT2         SET NEW AMORTIZATION COST AT Q(4)
0C0CF2                             1020 EQWWUIP   EQU   *       (ESTABLISH Q WHICH WILL USE Q(4) AS A INTER PT)
0C0CF2 589C 20F8            037F8  1021          L     9,ADDRPQ2              LOAD REG9 WITH ADDR PQ TO BE ESTABL
0C0CF6 94FE 9C06      CC0C6        1022          NI    6(9),B'11111110'       SET POTENTIAL QUARRY INDICATOR TO 0
0C0CFA 509C 2098            03798  1023          ST    9,APQTBD               STORE ADDR IN ADDR PQ TO BE DELETED
0C0CFE 58F0 2028            03728  1024          L     15,ASRDPQ              CALL SUBROUTINE DELETE PQ
0C0DC2 C5EF                        1025          BALR  14,15                  ''
0C0DC4 9211 22C8      C39C8        1026          MVI   CARCONT,X'11'          WRITE & SKIP 1
0C0DC8 D23C 22DC 25C7 039DD 03C07  1027          MVC   OUTLINE+20(L'MDPQAQ),MDPQAQ   MOVE MESSAGE TO OUTLINE
0C0DCE 48B9 CCCC            0CC00  1028          LH    11,0(9)                LOAD ROW INTO REG11
0CCD12 4EBC 2CCC            037C0  1029          CVD   11,DW                  CONVERT TO DECIMAL
0C0D16 DE03 22F6 2CC6 C39F6 037C6  1030          ED    OUTLINE+45(4),DW+6     EDIT ROW
0C0D1C 48B9 CC02            0C002  1031          LH    11,2(9)                LOAD COL INTO REG11
0C0D2C 4EBC 2CCC            037C0  1032          CVD   11,DW                  CONVERT TO DECIMAL
0C0D24 DE03 22FC 2CC6 C39FC 037C6  1033          ED    OUTLINE+51(4),DW+6     EDIT COLUMN
0CCD2A 58FC 2C4C            0374C  1034          L     15,ALINEOUT            CALL PRINT ROUTINE
0C0D2E 05EF                        1035          BALR  14,15                  ''
0C0D3C 5090 2084            03784  1036          ST    9,AQTBA                STORE ADDR IN ADDR QUARRY TO BE ADDE
0C0D34 D2C0 9CC7 4CC7 CC007 0CCC7  1037          MVC   7(1,9),7(4)                SET OWNER PQ(9) TO OWNER Q(4)
0C0D3A 58FC 2C14            03714  1038          L     15,ASRAQ               CALL SUBROUTINE ADD QUARRY
0C0D3E 05EF                        1039          BALR  14,15                  ''
0C0D4C 924E 9C05      CC005        1040          MVI   5(9),B'01001110'       SET PQ 9 TO S&G QUARRY W/O PP THAT
                                   1041 *                                     REQUIRES AN INTERMEDIATE POINT
0C0D44 961C 4C05      CC0C5        1042          OI    5(4),B'00010000'       SET Q4 TO IT IS AN INTERMEDIATE PT
                                   1043 *                                     AND WISHES TO SELF PRESERVE
0C0D48                             1044 PRINTIPM EQU   *                      (PRINT INTERMEDIATE POINT MESSAGE)
0C0D48 58BC 4C08            00008  1045          L     11,8(0,4)              LOAD REG11 WITH REMAINING LIFE Q(4)
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                      F01AUG68   5/30/69

0C0D4C 1288                        1046          LTR   11,11               IS LIFE 0 OR NEGATIVE
0C0D4E 4700 C29A             0005A 1047          BNP   DACCMW2             IF YES GO TO DACCMW2
0C0D52 5ABC 214C             0384C 1048          A     11,MWTD             OTHERWISE ADD TO MATERIAL WASTED
                                   1049 *                                  TO DATE
0C0D56 5080 214C             0384C 1050          ST    11,MWTD             UPDATE MATERIAL WASTED TO DATE
0C0D5A                             1051 DACCMW2  EQU   *
0C0D5A 9209 22C8       039C8       1052          MVI   CARCONT,X'09'       SET CARRIAGE CONTROL
0C0D5E D26B 22DD 249E 039DD 0389E  1053          MVC   OUTLINE+20(L'M42),M42 MOVE MESSAGE TO OUTPUT LINE
0C0C64 4884 0CC0             0C0C0 1054          LH    11,0(4)             MOVE ROW TO REG11
0C0D68 4EBC 2CCC             03700 1055          CVD   11,DW               CONVERT ROW TO DECIMAL
0C0D6C DE03 22EC 2006 039EC 03706  1056          ED    OUTLINE+35(4),DW+6  EDIT ROW
0C0D72 4884 C002             0C002 1057          LH    11,2(4)             LOAD REG11 WITH COLUMN
0C0D76 4EBC 2CCC             03700 1058          CVD   11,DW               CONVERT COLUMN TO DECIMAL
0C0D7A DE03 22F2 2006 039F2 03706  1059          ED    OUTLINE+41(4),DW+6  EDIT COLUMN
0C0D8C 58F0 204C             0374C 1060          L     15,ALINEOUT         CALL OUTPUT ROUTINE
0C0D84 05EF                        1061          BALR  14,15               ''
0C0D86 9211 22C8       039C8       1062          MVI   CARCONT,X'11'       SET CARRIAGE CONTROL CHARACTER
0C0D8A D222 22DD 243F 039DD 0383F  1063          MVC   OUTLINE+20(L'M36),M36  MOVE MESSAGE TO OUTPUT FIELD
0C0D9C 58BC 4C08             0C0C8 1064          L     11,8(0,4)           MOVE LIFE OF Q(4) TO REG11
0C0D94 12BB                        1065          LTR   11,11               IS LIFE POSITIVE
0C0D96 472C C2DC             00D9C 1066          BP    EDLIFE1             IF YES GO TO EDLIFE1
0C0D9A 1BBB                        1067          SR    11,11               OTHERWISE SET LIFE TO 0
0C0D9C 4EBC 2CCC             03700 1068 EDLIFE1  CVD   11,DW               CONVERT LIFE TO DECIMAL
0C0DAC DF09 22FC 2004 039F0 037C4  1069          ED    OUTLINE+39(10),DW+4  EDIT LIFE
0C0DA6 58FC 2C4C             0374C 1070          L     15,ALINEOUT         CALL OUTPUT ROUTINE
0C0DAA 05EF                        1071          BALR  14,15               ''
0C0DAC 47FC C116             00BD6 1072          B     UPDTR4              GO TO UPDTR4
0C0DBC                             1073 Q4PCNC   EQU   *                   (Q(4) PROCESSING CAN NOT CONTINUE)
0C0DBC 9201 23FC       C3AF0       1074          MVI   STRATEGY,X'01'      SET STRATEGY BYTE
0C0DB4 504C 21C0             03800 1075          ST    4,QIQ               STORE Q(4) ADDR IN QIQ
0C0DB8 58F0 2044             03744 1076          L     15,ASRPQCST         CALL SUBROUTINE PQCOST
0C0DBC 05EF                        1077          BALR  14,15               ''
0C0DBE 9501 23F1       C3AF1       1078          CLI   PTPQF,X'01'         WERE ANY PROCESSING PQ'S FOUND
0C0DC2 477C C37C             00E30 1079          BNE   WANPTF              IF NOT, GO TO WANPTF
                                   1080 *  AT THIS POINT, PROCESSING TYPE PQ WAS FOUND AND WILL BE OPENED
                                   1081 *  AS A QUARRY WITH A PROCESSING PLANT
0C0DC6 589C 2CF4             037F4 1082 EQWPP    L     9,ADDRPQ1           LOAD REG9 WITH ADDR PQ TO BE ESTABL
0C0DCA 94FE 9CC6       CC006       1083          NI    6(9),B'11111110' SET PQ INDICATOR TO 0
0C0DCE 5C9C 2098             03798 1084          ST    9,APQTBD            STORE ADDR IN ADDR PQ TO BE DELETED
0C0CD2 58FC 2028             03728 1085          L     15,ASRDPQ           CALL SUBROUTINE DELETE PQ
0C0CD6 05EF                        1086          BALR  14,15               ''
0C0CD8 9211 22C8       C39C8       1087          MVI   CARCONT,X'11'       WRITE & SKIP 1
0C0CDC D23C 22DD 25C7 C39DD 03C07  1088          MVC   OUTLINE+20(L'MDPQAQ),MDPQAQ   MOVE MESSAGE TO OUTLINE
0C0CE2 4889 CCCC             0CCC0 1089          LH    11,0(9)             LOAD ROW INTO REG11
0C0CE6 4EBC 2CCC             03700 1090          CVD   11,DW               CONVERT TO DECIMAL
0C0CEA DF03 22F6 7CC6 C39F6 03706  1091          ED    OUTLINE+45(4),DW+6  EDIT ROW
0C0CFC 4889 CCC2             0C002 1092          LH    11,2(9)             LOAD COL INTO REG11
0C0CF4 4EBC 2CCC             037C0 1093          CVD   11,DW               CONVERT TO DECIMAL
0C0CF8 DE03 22FC 2CC6 039FC 03706  1094          ED    OUTLINE+51(4),DW+6  EDIT COLUMN
0C0CF8 58F0 204C             0374C 1095          L     15,ALINEOUT         CALL PRINT ROUTINE
0C0EC2 05EF                        1096          BALR  14,15               ''
0C0EC4 5C9C 2C84             03784 1097          ST    9,AQTBA             STORE ADDR IN ADDR Q TO BE ADDED
0C0EC8 D2CC 9007 4CC7 CC0C7 0C007  1098          MVC   7(1,9),7(4)              SET OWNER PQ(9) TO OWNER Q(4)
0C0ECE 58F0 2C14             03714 1099          L     15,ASRAQ            CALL SUBROUTINE ADD QUARRY
0C0E12 05EF                        1100          BALR  14,15               ''
0C0E14 924B 9005       CC0C5       1101          MVI   5(9),B'01001011'    SET Q = S&G, PP, AND SELF PRESERVE
0C0E18 D201 902E 20EA C002E 037EA  1102          MVC   46(2,9),AMORT1+2    SET COST TO PROCESS
0C0E1E 47FC C138             00BF8 1103          B     ZONOUTQ4            GO TO ZONOUTQ4
0C0E22                             1104 Q4NPP    EQU   *                   (Q(4) NOT A PROCESSING PLANT)
0C0E22 9201 23FC       03AF0       1105          MVI   STRATEGY,X'01'      SET STRATEGY BYTE
0C0E26 504C 21CC             03800 1106          ST    4,QIQ               STORE ADDR Q(4) IN QIQ
0C0E2A 58FC 2044             03744 1107          L     15,ASRPQCST         CALL SRPQCST
0C0E2E C5EF                        1108          BALR  14,15               ''
0C0E3C 9501 23F2       03AF2       1109 WANPTF   CLI   NPTPQF,X'01'        WAS A NON PROCESSING PQ FOUND
0C0E34 477C C3D4             00E94 1110          BNE   WAPTF               IF NOT, GO TO WAPTF
                                   1111 *  AT THIS POINT A NON-PROCESSING PQ WAS FOUND -- ADDR IN ADDRPQ3
0C0E38 5890 20FC             037FC 1112          L     9,ADDRPQ3           LOAD ADDR OF PQ TO BE ESTAB INTO 9
0C0E3C 94FE 9C06       C0006       1113          NI    6(9),X'FE'          SET PQ INDICATOR TO 0
0C0E4C 509C 2098             03798 1114          ST    9,APQTBD            STORE ITS ADDR IN PQ TO BE DELETED
0C0E44 58F0 2028             03728 1115          L     15,ASRDPQ           CALL SUBROUTINE DELETE PQ
0C0E48 C5EF                        1116          BALR  14,15               ''
0C0E4A 9211 22C8       039C8       1117          MVI   CARCONT,X'11'       WRITE & SKIP 1
0C0E4E D23C 22DD 25C7 C39CD 03C07  1118          MVC   OUTLINE+20(L'MDPQAQ),MDPQAQ   MOVE MESSAGE TO OUTLINE
0C0E54 48B9 CCCC             0CCC0 1119          LH    11,0(9)             LOAD ROW INTO REG11
0C0E58 4EBC 2CCC             037C0 1120          CVD   11,DW               CONVERT TO DECIMAL
0C0E5C DE03 22F6 2006 C39F6 037C6  1121          ED    OUTLINE+45(4),DW+6  EDIT ROW
0C0E62 48B9 CC02             0C002 1122          LH    11,2(9)             LOAD COL INTO REG11
0C0E66 4EBC 2CC0             037C0 1123          CVD   11,DW               CONVERT TO DECIMAL
0C0E6A DE03 22FC 2C06 039FC 03706  1124          ED    OUTLINE+51(4),DW+6  EDIT COLUMN
0C0E7C 58F0 204C             0374C 1125          L     15,ALINEOUT         CALL PRINT ROUTINE
0C0E74 05EF                        1126          BALR  14,15               ''
0C0E76 5C90 2084             03784 1127          ST    9,AQTBA             STORE ITS ADDR IN ADDR Q TO BE ADDED
000E7A D2CC 9007 40C7 CC007 0C007  1128          MVC   7(1,9),7(4)              SET OWNER PQ(9) TO OWNER Q(4)
0C0E8C 58F0 2C14             03714 1129          L     15,ASRAQ            CALL SUBROUTINE ADD QUARRY
0C0E84 05EF                        1130          BALR  14,15               ''
0C0E86 924A 9C05       C0005       1131          MVI   5(9),B'01001010'    SET Q TO S&G, NO PP, SELF PRESERVE
0C0E8A D201 902E 20F2 C002E 037F2  1132          MVC   46(2,9),AMORT3+2    SET COST TO PROCESS
0C0E9C 47FC C138             008F8 1133          B     ZONOUTQ4            GO TO ZONOUTQ4
0C0E94 9501 23F1       C3AF1       1134 WAPTF    CLI   PTPQF,X'01'         WAS A PROCESSING PQ FOUND
0C0E98 4780 C306             00DC6 1135          BE    EQWPP               IF YES GO TO EQWPP
0C0E9C 47F0 C138             008F8 1136          B     ZONOUTQ4            OTHERWISE, GO TO ZONOUTQ4
0C0EAC                             1137 IWACSQ   EQU   *                   (IT WAS A CRUSHED STONE QUARRY)
000EAC 9180 4005       C0005       1138          TM    5(4),X'80'          HAS Q(4) BEEN ZONED OUT
0C0EA4 4710 C3F6             00EB6 1139          BO    CSQWASZO            IF YES, GO TO CS Q WAS ZONED OUT
                                   1140 *  AT THIS POINT, Q(4) WAS NOT ZONED OUT
000EA8 585C 4C08             0C008 1141          L     5,8(0,4)            LOAD LIFE OF Q(4) INTO REG5
000EAC 1255                        1142          LTR   5,5                 IS LIFE 0 OR -
0C0EAE 47C0 C404             0CEC4 1143          BC    12,CSQWASDP         IF YES, GO TO CS Q WAS DEPLETED
0C0EB2 47FC C116             00BD6 1144          B     UPDTR4              OTHERWISE GO TO UPDTR4
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                                F01AUG68   5/30/69

000EB6                              1145 CSQWASZO EQU   *                      (CRUSHED STONE Q WAS ZONED OUT)
000EB6 5040 20D0            037D0   1146          ST    4,APPTBM               STORE ADDR OF PP TO BE MOVED
000EBA 58F0 2040            03740   1147          L     15,ASRADEPP            CALL ALLOWANCE ON EXISTING
000EBE 05EF                         1148          BALR  14,15                  PROCESSING PLANT SUBROUTINE
000EC0 47F0 C40A            00ECA   1149          B     BEGSPCS                GO TO BEGSPCS
000EC4                              1150 CSQWASDP EQU   *                      (CRUSHED STONE Q WAS DEPLETED)
000EC4 D203 20CC C980 037CC 01440   1151          MVC   ADEPP(4),=F'0'         SET ALLOWANCE ON PP AT Q(4) =0
000ECA                              1152 BEGSPCS  EQU   *                      (BEGIN CS SELF-PRESERVATION ROUTINE)
000ECA 9108 4005      00005         1153          TM    5(4),X'08'             DOES OWNER WISH TO SELF PRESERVE
000ECE 4780 C138            00BF8   1154          BZ    ZONOUTQ4               IF NOT, GO TO ZONOUTQ4
000ED2 D203 20B4 20CC 037B4 037C0   1155          MVC   POINT2(4),WGCCS        SET DESTINATION = WGC CRUSH STONE
000ED8 5890 2064            03764   1156          L     9,SQCH                 LOAD REG9 WITH START Q CHAIN
000EDC 1299                         1157 CSQLOOP  LTR   9,9                    IS CONTENTS OF REG9 NEG
000EDE 4740 C458            00F18   1158          BM    CSQOHNMQ               IF SO, GO TO CSQOHNMQ
000EE2 1949                         1159          CR    4,9                    IS Q(4) THE SAME Q AS Q(9)
000EE4 4780 C450            00F10   1160          BE    CSUPPTR9               IF SAME Q GO TO CSUPPTR9
000EE8 D500 4007 9007 00007 00007   1161          CLC   7(1,4),7(9)            IS Q(9) OWNED BY SAME OWNER AS Q(4)
000EEE 4770 C450            00F10   1162          BNE   CSUPPTR9               IF NOT GO TO CSUPPTR9
000EF2 9180 9005      00005         1163          TM    5(9),X'80'             HAS Q(9) BEEN ZONED OUT
000EF6 4710 C450            00F10   1164          BO    CSUPPTR9               IF SO GO TO CSUPPTR9
000EFA 58B0 9008            00008   1165          L     11,8(0,9)              LOAD LIFE Q(9) INTO REG11
000EFE 59B0 900C            0000C   1166          C     11,12(0,9)             COMPARE REMAINING LIFE WITH MAXIMUM
                                    1167 *                                     YEARLY OUTPUT
000F02 4740 C450            00F10   1168          BL    CSUPPTR9               IF LIFE LESS THAN 1 YEAR, GO TO
                                    1169 *                                     CSUPPTR9
                                    1170 *  AT THIS POINT, THE QUARRY OPERATOR HAS MORE THAN 1 ACTIVE QUARRIES
                                    1171 *  THE NEW QUARRY WILL BE THE ONE WHICH WILL SUPPLY THE ZONED OUT
                                    1172 *  OR DEPLETED ONE AT THE LOWEST COST RATHER THAN THE WEIGHTED
                                    1173 *  GEOMETRIC CENTER
000F06                              1174 CSQHAQ   EQU   *                      (CS Q OWNER HAS ANOTHER Q)
000F06 D203 20B4 4000 037B4 00000   1175          MVC   POINT2(4),0(4)         SET POINT2 = QUARRY IN REG4
000F0C 47F0 C458            00F18   1176          B     CSQOHNMQ               GO TO CSQOHNMQ
000F10 5890 9034            00034   1177 CSUPPTR9 L     9,52(0,9)              LOAD REG9 WITH ADDR OF NEXT Q
000F14 47F0 C41C            00EDC   1178          B     CSQLOOP                GO TO CSQLOOP
000F18                              1179 CSQOHNMQ EQU   *            (CRUSHED STONE Q OWNER HAS NO MORE QUARRIES)
000F18 9200 23F3      03AF3         1180          MVI   CSPQI,X'00'            SET CS PQ INDICATOR TO 0
000F1C D203 2104 213C 03804 0383C   1181          MVC   COSTCMP1,LARPOSN       SET COSTCMP1 = LARGEST POSITIVE NO.
000F22 5890 2068            03768   1182          L     9,SPQCH                LOAD REG9 WITH START PQ CHAIN
000F26 1299                         1183 CSPQTEST LTR   9,9                    IS CONTENTS OF REG9 NEG
000F28 4740 C4F4            00FB4   1184          BM    DSCSPQ                 IF YES GO TO DSCSPQ
000F2C D500 4007 9007 00007 00007   1185          CLC   7(1,4),7(9)            IS PQ(9) OWNED BY SAME OWNER AS Q(4)
000F32 4780 C47E            00F3E   1186           BE    TESTCS                IF YES, GO TO TESTCS
000F36 95C0 9007      00007         1187           CLI   7(9),X'00'            IS THE LAND AVAILABLE
000F3A 4770 C4EC            00FAC   1188          BNE   UCSPQPTR               IF NOT, GO TO UCSPQPTR
000F3E 9120 9006      00006         1189 TESTCS   TM    6(9),X'20'             IS PQ(9) A CRUSHED STONE PQ
000F42 4780 C4EC            00FAC   1190          BZ    UCSPQPTR               IF NOT, GO TO UCSPQPTR
000F46 9180 9006      00006         1191          TM    6(9),X'80'             HAS PQ(9) BEEN ZONED OUT
000F4A 4710 C4EC            00FAC   1192          BO    UCSPQPTR               IF YES, GO TO UCSPQPTR
                                    1193 *  AT THIS POINT REG9 CONTAINS A CRUSHED STONE POTENTIAL QUARRY OWNED
                                    1194 *   BY THE SAME OWNER AS Q(4) AND IT HAS NOT BEEN ZONED OUT
000F4E 9201 23F3      03AF3         1195          MVI   CSPQI,X'01'            SET CS PQ INDICATOR TO 1 (A PQ FOUND
000F52 D203 20B0 9000 037B0 00000   1196          MVC   POINT1(4),0(9)         SET POINT1 = ADDR PQ(9)
000F58 58F0 2034            03734   1197          L     15,ASRDIST             CALL SUBROUTINE DETERMINE DISTANCE
000F5C 05EF                         1198          BALR  14,15                  ''
000F5E D203 20C4 20A4 037C4 037A4   1199          MVC   TRANSD(4),DISTX        SET PARAMETER FOR TRANSPORTATION CST
000F64 58F0 2038            03738   1200          L     15,ASRTRCST            CALL SUBROUTINE TRANSPORTATION COST
000F68 05EF                         1201          BALR  14,15                  ''
000F6A 1B66                         1202          SR    6,6                    CLEAR REG 6
000F6C 5870 9010            00010   1203          L     7,16(0,9)              LOAD ESTABLISHMENT COST INTO REG7
000F70 5C60 20CC            037CC   1204          M     6,ADEPP                MULTIPLY BY ALLOWANCE ON Q(4) PP
000F74 5D60 C984            01444   1205          D     6,=F'10'               & DIVIDE BY 10 FOR ALLOWANCE
000F78 5860 9010            00010   1206          L     6,16(0,9)              LOAD ESTABLISHMENT COST INTO REG6
000F7C 1B67                         1207          SR    6,7                    SUBTRACT ALLOWANCE FROM EST COST
000F7E 1876                         1208          LR    7,6                    LOAD NEW EST COST INTO REG7
000F80 1B66                         1209          SR    6,6                    CLEAR REG6
000F82 5C60 214C            03840   1210          M     6,HUNDRED              CONVERT EST COST TO PENNIES
000F86 5D60 9008            00008   1211          D     6,8(0,9)               DIVIDE BY LIFE FOR AMORTIZATION COST
000F8A 4070 C8CC            0138C   1212          STH   7,AMORTCS              STORE AMORTIZATION COST IN CSAMORTCS
000F8E 4A70 9014            00014   1213          AH    7,20(0,9)              ADD COST TO MINE
000F92 5A70 20C8            037C8   1214          A     7,FIXPTCST             ADD TRANSPORTATION COST
000F96 5970 2104            03804   1215          C     7,COSTCMP1             COMPARE COST WITH PREVIOUS LOW COST
000F9A 4720 C4EC            00FAC   1216          BH    UCSPQPTR               IF COST IS HIGHER, GO TO UCSPQPTR
                                    1217 *                           OTHERWISE SET PREVIOUS LOW COST TO PRESENT CST
000F9E 5070 2104            03804   1218          ST    7,COSTCMP1             STORE NEW LOW COST IN COSTCMP1
000FA2 5090 20D4            037D4   1219          ST    9,ACSQTBE              STORE ADDR PQ(9) IN ACSQTBE
000FA6 D201 C8CE C8CC 0138E 0138C   1220          MVC   LAMORTCS(2),AMORTCS STORE AMORTIZATION COST IN LAMORTCS
000FAC 5890 9034            00034   1221 UCSPQPTR L     9,52(0,9)              LOAD REG9 WITH ADDR OF NEXT PQ
000FB0 47F0 C466            00F26   1222          B     CSPQTEST               GO TO CSPQTEST
000FB4 9501 23F3      03AF3         1223 DSCSPQ   CLI   CSPQI,X'01'            WERE ANY PQ'S FOUND
000FB8 4770 C138            00BF8   1224          BNE   ZONOUTQ4               IF NOT, GO TO ZONOUTQ4
                                    1225 *  AT THIS POINT THE PQ WHOSE ADDR IS IN ACSQTBE MUST BE ESTABLISHED
000FBC 5890 20D4            037D4   1226          L     9,ACSQTBE              LOAD REG9 WITH ADDR PQ TO BE EST
000FC0 D201 902E C8CE 0002E 0138E   1227          MVC   46(2,9),LAMORTCS       SET NEW AMORTIZATION COST
000FC6 9223 9005      00005         1228          MVI   5(9),B'00100011'       ESTABLISH PQ(9) AS A CS QUARRY
000FCA D200 9007 4007 00007 00007   1229          MVC   7(1,9),7(4)                 SET OWNER PQ(9) TO OWNER Q(4)
000FD0 94FC 9006      00006         1230          NI    6(9),B'11111100'       CHANGE PQ INDICATOR TO 0
000FD4 5090 2098            03798   1231          ST    9,APQTBD               STORE ADDR PQ TO BE DELETED
000FD8 58F0 2028            03728   1232          L     15,ASRDPQ              CALL SUBROUTINE DELETE PQ
000FDC 05EF                         1233          BALR  14,15                  ''
000FDE 9211 22C8      039C8         1234          MVI   CARCONT,X'11'          WRITE & SKIP 1
000FE2 D23C 22DD 2507 039DD 03C07   1235          MVC   OUTLINE+20(L'MDPQAQ),MDPQAQ   MOVE MESSAGE TO OUTLINE
000FE8 48B9 0000            00000   1236          LH    11,0(9)                LOAD ROW INTO REG11
000FEC 4EB0 20C0            037C0   1237          CVD   11,DW                  CONVERT TO DECIMAL
000FF0 DE03 22F6 20C6 039F6 037C6   1238          ED    OUTLINE+45(4),DW+6     EDIT ROW
000FF6 48B9 0002            00002   1239          LH    11,2(9)                LOAD COL INTO REG11
000FFA 4EB0 20C0            037C0   1240          CVD   11,DW                  CONVERT TO DECIMAL
000FFE DE03 22FC 20C6 039FC 037C6   1241          ED    OUTLINE+51(4),DW+6     EDIT COLUMN
001004 58F0 204C            0374C   1242          L     15,ALINEOUT            CALL PRINT ROUTINE
001008 05EF                         1243          BALR  14,15                  ''
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT    SOURCE STATEMENT                                           F01AUG68   5/30/69

00100A 5090 2084            03784  1244            ST    9,AQTBA              STORE ADDR QUARRY TO BE ADDED
001COE 58FC 2014            03714  1245            L     15,ASRAQ             CALL SUBROUTINE ADD QUARRY
0C1C12 05EF                        1246            BALR  14,15                ''
0C1C14 47FC C138            008F8  1247            B     ZONOUTQ4             GO TO ZONOUTQ4
0C1C18                             1248 OHAQ       EQU   *                    (OWNER HAS ANOTHER QUARRY)
0C1C18 9200 C860      01320        1249            MVI   IPCOUNT,X'00'        SET IPCOUNT * 0
0C1C1C 9200 C861      01321        1250            MVI   UIPCOUNT,X'00'       SET UIPCOUNT = 0
001C2C D257 C864 C863 01324 01323  1251            MVC   IPCHAIN(88),IPCHAIN-1   SET IPCHAIN AND UIPCHAIN = -1
0C1C26 5870 C858            0131R  1252            L     7,AIPCHAIN           LOAD REG7 WITH ADDR IP CHAIN
0C1C2A 5880 C85C            0131C  1253            L     8,AUIPCH             LOAD REG8 WITH ADDR UIP CHAIN
0C1C2E 1949                        1254 OHAQLP     CR    4,9                  IS Q(4) SAME Q AS Q(9)
0C1C3C 4780 C5E6            010A6  1255            BE    UPQPTR9              IF YES GO TO UPQPTR9
001034 9140 9005      C00C5        1256            TM    5(9),X'40'           IS IT A S&G QUARRY
0C1C38 478C C5E6            010A6  1257            BZ    UPQPTR9              IF NOT GO TO UPQPTR9
0C103C D5CC 4007 9C07 CC007 00007  1258            CLC   7(1,4),7(9)          IS Q(9) OWNED BY SAME OWNER Q(4)
001042 4770 C5E6            010A6  1259            BNE   UPQPTR9              IF YES, GO TO UPQPTR9
0C1C46 911C 9CC5      CC0C5        1260            TM    5(9),X'10'           IS Q(9) AN INTERMEDIATE POINT
0C104A 471C C588            01078  1261            BO    CANPC                IF YES, GO TO CANPC
0C1C4E 91C4 9C05      CC005        1262 DQUIP      TM    5(9),X'04'           DOES Q(9) USE AN INTER PT
001C52 478C C5E6            010A6  1263            BZ    UPQPTR9              IF NOT GO TO UPQPTR9
                                   1264 *  AT THIS POINT Q(9) USES AN INTERMEDIATE POINT
001C56 1B66                        1265            SR    6,6                  CLEAR REG6
0C1C58 436C C861            01321  1266            IC    6,UIPCOUNT           INSERT UIPCOUNT INTO REG6
0C1C5C 4160 6001            0CC01  1267            LA    6,1(0,6)             ADD 1 TO UIPCOUNT
0C1C6C 426C C861            01321  1268            STC   6,UIPCOUNT           STORE UPDATED COUNT
0C1C64 556C C984            01444  1269            CL    6,=F'10'             DO WE HAVE MORE THAN 10 Q'S IN CHAIN
0C1C68 472C C5F4            01084  1270            BH    TMEITCH              IF YES, GO TO TMEITCH
0C1C6C 5090 8CCC            0CC00  1271            ST    9,0(0,8)             STORE ADDR Q(9) IN UIP CHAIN
0C1C7C 418C 8C04            00004  1272            LA    8,4(0,8)             POINT REG8 AT NEXT LINK IN UIP CHAIN
0C1C74 47FC C5E6            010A6  1273            B     UPQPTR9              GO TO UPQPTR9
0C1078 9101 9C04      C0004        1274 CANPC      TM    4(9),X'01'           CAN PROCESSING CONTINUE
CC1C7C 471C C5C4            01084  1275            BO    UPIPC                IF YES GO TO UPIPC
001C8C 47FC C58E            0104E  1276            B     DQUIP                OTHERWISE GO TO DQUIP
                                   1277 *  AT THIS POINT, Q(9) IS AN INTERMEDIATE POINT
0C1C84 1B66                        1278 UPIPC      SR    6,6                  CLEAR REG 6
0C1C86 436C C86C            01320  1279            IC    6,IPCOUNT            INSERT IP COUNT INTO REG6
0C108A 416C 6001            00001  1280            LA    6,1(0,6)             ADD 1 TO IPCOUNT
001C8E 4260 C86C            01320  1281            STC   6,IPCOUNT            STORE UPDATED IP COUNT
0C1092 556C C984            01444  1282            CL    6,=F'10'             DO WE HAVE MORE THAN 10 ENTRIES
0C1096 472C C5F4            010B4  1283            BH    TMEITCH              IF YES GO TO TMEITCH
0C109A 509C 7CCC            0C000  1284            ST    9,0(0,7)             STORE ADDR Q(9) IN IP CHAIN
00109E 417C 7C04            0CC04  1285            LA    7,4(0,7)             POINT REG7 AT NEXT LINK IN IP CHAIN
0C1CA2 47FC C58E            0104E  1286            B     DQUIP                GO TO DQUIP
0C1CA6 589C 9034            00034  1287 UPQPTR9    L     9,52(0,9)            POINT REG9 AT NEXT Q IN CHAIN
0C1CAA 1299                        1288            LTR   9,9                  IS ADDR NEG
0C1CAC 4720 C56E            0102E  1289            BP    OHAQLP             IF NOT, WE ARE NOT DONE. GO TO OHAQLP
001C8C 47FC C63C            010F0  1290            B     OHAQS                OTHERWISE, GO TO OHAQS
0C1C84                             1291 TMEITCH    EQU   *                    (TOO MANY ENTRIES IN TEMP CHAIN)
0C1C84 D23B 22E7 2462 039E7 03B62  1292            MVC OUTLINE+30(L'M37),M37    MOVE ERROR MESSAGE TO OUTLINE
CC1CBA 58FC 204C            0374C  1293            L     15,ALINEOUT          CALL OUTPUT ROUTINE
001CBE 05EF                        1294            BALR  14,15                ''
                                   1295            CLOSE (INDCB,,OUTDCB)
0C1CCC                             1296+           CNOP  0,4
0C1CCC 451C C6CC            010CC  1297+           BAL   1,*+12 BRANCH AROUND LIST
0C1CC4 C0                          1298+           DC    AL1(0) OPTION BYTE
0C1CC5 C008C4                      1299+           DC    AL3(INDCB) DCB ADDRESS
0C10C8 80                          1300+           DC    AL1(128) OPTION BYTE
0C1CC9 CC09A4                      1301+           DC    AL3(OUTDCB) DCB ADDRESS
0010CC 0A14                        1302+           SVC   20 ISSUE CLOSE SVC
                                   1303            REEXIT
0C1CCE 181D                        1304+           LR    1,13
0C1CDC 58D0 DC04            0CC04  1305+           L     13,4(,13)
0C1CD4                             1306+           CNOP  0,4
0C1CD4 47FC C61C            010DC  1307+           B     *+8 BRANCH AROUND SP+LV
0C1CD8 C0                          1308+           DC    AL1(0) SUBPOOL VALUE
0C10D9 CCC048                      1309+           DC    AL3(72) LENGTH
0C1CDC 58CC C618            010D8  1310+           L     0,*-4 LOAD SP AND LV
0C1CEC CA0A                        1311+           SVC   10 ISSUE FREEMAIN SVC
0C1CE2 98EC D00C            0C00C  1312+           LM    14,12,12(13) RESTORE THE REGISTERS
0C1CE6 92FF DCOC      000CC        1313+           MVI   12(13),X'FF' SET RETURN INDICATION
001CEA 41F0 CCC0            00000  1314+           LA    15,0(0,0) LOAD RETURN CODE
0C1CEE 07FE                        1315+           BR    14 RETURN
0C1CF0                             1316 OHAQS      EQU   *                    (CHAINS ARE SET, DETERMINE STRATEGY)
0C1CFC 9101 4005      CC005        1317            TM    5(4),X'01'           WAS Q(4) A PROCESSING PLANT
0C10F4 4710 C726            011E6  1318            BO    Q4WPP                IF YES, GO TO Q4WPP
                                   1319 *  AT THIS POINT, Q(4) WAS NOT A PROCESSING PLANT
0C1CF8 9104 4005      CC005        1320            TM    5(4),X'04'           WAS Q(4) USING AN INTERMEDIATE POINT
0010FC 4780 C6F8            011B8  1321            BZ    Q4NPPNIP             IF NOT, GO TO QJNPPNIP
0011CC 784C C988            01448  1322            LE    4,=X'46FFFFFF'       SET FLT PT REG4 = LARGE NO
0C11C4 D203 C8C0 206C 01380 03760  1323            MVC   CLOSIP(4),MINONE     SET CLOSIP = -1
00110A D203 20B0 40CC C37B0 000C0  1324            MVC   POINT1(4),0(4)       SET POINT1 = Q(4)
0C111C 1888                        1325            SR    8,8                  CLEAR INDEX REG8 FOR INDEXING
001112 5898 C864            01324  1326 SDIPLP     L     9,IPCHAIN(8)         LOAD ADDR INTER PT INTO REG9
0C1116 1299                        1327            LTR   9,9                  ARE WE DONE WITH ALL IP'S
001118 4740 C680            01140  1328            BM    CIPD                 IF YES GO TO CIPD
0C111C D203 2084 9CCC 037B4 000C0  1329            MVC   POINT2(4),0(9)       SET POINT2 = Q(9)
001122 58F0 2C34            03734  1330            L     15,ASRDIST           FIND DISTANCE Q(4) TO Q(9) --
001126 05EF                        1331            BALR  14,15                CALL SUBROUTINE DIST
001128 7820 2CA4            037A4  1332            LE    2,DISTX              LOAD DIST INTO FLT PT REG2
00112C 3924                        1333            CER   2,4                  IS DISTANCE Q(4) TO Q(9) SHORTER
                                   1334 *                                     THAN PREVIOUS SHORT
0C112E 472C C678            01138  1335            BH    CNIP                 IF NOT, GO TO CNIP
0C1132 5090 C8C0            01380  1336            ST    9,CLOSIP             STORE ADDR OF IP IN CLOSIP
001136 3842                        1337            LER   4,2                  STORE NEW SHORT DISTANCE IN REG4
001138 4180 8004            00004  1338 CNIP       LA    8,4(0,8)             INCREASE INDEX REG8 TO POINT AT
                                   1339 *                                     NEXT INTERMEDIATE POINT IN CHAIN
00113C 47F0 C652            01112  1340            B     SDIPLP               GO TO SDIPLP
00114C                             1341 CIPD       EQU   *                    (CLOSEST INTER PT DETERMINED)
00114C D503 C8C0 2060 C1380 03760  1342            CLC   CLOSIP(4),MINONE     WERE ANY INTERMEDIATE POINTS FOUND
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                            F01AUG68   5/30/69

001146 4780 C138            008F8  1343          BE    ZONOUTQ4             IF NOT, GO TO ZONOUTQ4
0C114A 9202 23FC      03AF0        1344          MVI   STRATEGY,X'02'       SET STRATEGY = 2 (IP ONLY)
0C114E D203 2100 C8C0 03800 01380  1345          MVC   QIQ(4),CLOSIP        SET QIQ = CLOSEST INTER POINT
0C1154 58F0 2044            03744  1346          L     15,ASRPQCST          CALL SRPQCOST TO FIND A PQ
0C1158 05EF                        1347          BALR  14,15                 WHICH WILL SUPPLY THE INTERMEDIATE
                                   1348 *                                    POINT CLOSEST TO Q(4) AT THE
                                   1349 *                                    LOWEST COST
0C115A 9501 23F1      C3AF1        1350          CLI   PTPQF,X'01'          WERE ANY PQ'S FOUND
0C115E 477C C138            008F8  1351          BNE   ZONOUTQ4             IF NOT, GO TO ZONOUTQ4
0C1162 5890 20F8            037F8  1352          L     9,ADDRPQ2            LOAD LOWESTBCOST PQ INTO REG9
0C1166 924E 9C05      C0005        1353          MVI   5(9),B'01001110'     SET PQ(9) TO A S&G PQ, USING AN IP
00116A D200 9C07 4007 00007 0C007  1354          MVC   7(1,9),7(4)          SET OWNERSHIP TO SAME AS Q(4)
0C117C                             1355 DPQAQ    EQU   *                    (DELETE PQ, ADD Q)
0C1170 5090 2098            03798  1356          ST    9,APQTBD             STORE IN ADDR OF PQ TO BE DELETED
0C1174 58F0 2C28            03728  1357          L     15,ASRDPQ            DELETE IT (CALL SUBROUTINE DELETE Q)
0C1178 05EF                        1358          BALR  14,15                ''
0C117A 9211 22C8      C39C8        1359          MVI   CARCONT,X'11'        WRITE & SKIP 1
0C117E D23C 22DD 25C7 039DD 03C07  1360          MVC   OUTLINE+20(L'MDPQAQ),MDPQAQ   MOVE MESSAGE TO OUTLINE
0C1184 4889 CCCC            0CCC0  1361          LH    11,0(9)              LOAD ROW INTO REG11
0C1188 4E80 2CC0            03700  1362          CVD   11,DW                CONVERT TO DECIMAL
00118C DE03 22F6 2CC6 C39F6 03706  1363          ED    OUTLINE+45(4),DW+6   EDIT ROW
0C1192 4889 0C02            00002  1364          LH    11,2(9)              LOAD COL INTO REG11
0C1196 4E8C 2CC0            03700  1365          CVD   11,DW                CONVERT TO DECIMAL
00119A DE03 22FC 2C06 039FC 03706  1366          ED    OUTLINE+51(4),DW+6   EDIT COLUMN
0C11A0 58F0 204C            0374C  1367          L     15,ALINEOUT          CALL PRINT ROUTINE
0C11A4 05EF                        1368          BALR  14,15                ''
0C11A6 94FE 9C06      C0006        1369          NI    6(9),X'FE'           SET PQ INDICATOR TO 0
0C11BA 5090 2084            03784  1370          ST    9,AQTBA              STORE 9 IN ADDR OF Q TO BE ADDED
0C11AE 58F0 2C14            03714  1371          L     15,ASRAQ             ADD Q (CALL SUBROUTINE ADD Q)
0C11B2 05EF                        1372          BALR  14,15                ''
0C11B4 47F0 C138            008F8  1373          B     ZONOUTQ4             GO TO ZONOUTQ4
0C11B8                             1374 Q4NPPNIP EQU   *                    (Q(4) NOT A PP, NOT USING A IP)
0C11B8 9204 23FC      C3AF0        1375          MVI   STRATEGY,X'04'       SET STRATEGY = 4 (FIND LOWEST COST
                                   1376 *                                   NON-PROCESSING PQ TO Q(4)
0C11BC 5040 21CC            03800  1377          ST    4,QIQ                STORE ADDR Q(4) IN QIQ
0C11CC 58F0 2C44            03744  1378          L 15,ASRPQCST              FIND LOWEST COST NON-PROCESSING PQ
0C11C4 05EF                        1379          BALR  14,15                ''
0C11C6 9501 23F2      03AF2        1380          CLI   NPTPQF,X'01'         WERE ANY FOUND
0C11CA 4770 C138            008F8  1381          BNE   ZONOUTQ4             IF NOT GO TO ZONOUTQ4
0C11CE 5890 20FC            037FC  1382          L     9,ADDRPQ3            SET REG9 = ADDR Q TO BE ESTABL
0C11D2 924A 90C5      C00C5        1383          MVI   5(9),B'01001010'     SET PQ(9) TO A S&G Q, SELF PRESERVE
                                   1384 *                                   WITH NO PROCESSING PLANT
0C11D6 D200 9CC7 4CC7 C00C7 0C007  1385          MVC   7(1,9),7(4)          SET OWNER = OWNER Q(4)
0C11DC D201 902E 20F2 C002E 037F2  1386          MVC   46(2,9),AMORT3+2     SET NEW AMORTIZATION COST
0C11E2 47F0 C6BC            01170  1387          B     DPQAQ                GO TO DPQAQ
0C11E6                             1388 Q4WPP    EQU   *                    (Q(4) WAS A PROCESSING PLANT)
0C11E6 911C 40C5      CC0C5        1389          TM    5(4),X'10'           WAS Q(4) BEING USED AS AN IP
0C11EA 471C C788            01248  1390          BO    Q4UAIP               IF YES, GO TO Q4UAIP
0C11EE 9101 4C04      CC0C4        1391          TM    4(4),X'01'           CAN PROCESSING CONTINUE
0C11F2 471C C764            01224  1392          BO    PCANC                IF YES, GO TO PCANC
                                   1393 *  AT THIS POINT, Q(4) IS NOT BEING USED AS AN INTER PT AND PROCESSING
                                   1394 *  CAN NOT CONTINUE
0C11F6                             1395 Q4PCNCO  EQU   *                    (Q(4) PROCESSING CAN NOT CONTINUE)
0C11F6 9205 23FC      C3AF0        1396          MVI   STRATEGY,X'05'       SET STRATEGY = 5 (FIND LOWEST COST
                                   1397 *                                   PQ TO Q(4) WITH A PP AT NEW Q
0C11FA 5040 21CC            03800  1398          ST    4,QIQ                STORE ADDR Q(4) IN QIQ
0C11FE 58FC 2C44            03744  1399          L     15,ASRPQCST          CALL SRPQCOST
0C12C2 05EF                        1400          BALR  14,15                ''
0C1204 9501 23F1      C3AF1        1401          CLI   PTPQF,X'01'          WERE ANY PQ'S FOUND
0C12C8 477C C138            008F8  1402          BNE   ZONOUTQ4             IF NOT GO TO ZONOUTQ4
0C12CC 5890 20F4            037F4  1403 EWPP     L     9,ADDRPQ1            LOAD REG9 WITH LOWEST COST PQ
0C121C 9248 9C05      C00C5        1404          MVI   5(9),B'01001011'     EST AS A S&G Q WITH A PP,SELF PRESER
0C1214 D201 902E 20EA C002E 037EA  1405          MVC   46(2,9),AMORT1+2     SET AMORTIZATION COST
0C121A D2CC 9C07 4CC7 CC007 00007  1406          MVC   7(1,9),7(4)          SET OWNER PQ(9) = OWNER Q(4)
00122C 47FC C6B0            0117C  1407          B     DPQAQ                GO TO DPQAQ
                                   1408 *  AT THIS POINT, Q(4) IS NOT BEING USED AS AN INTER PT AND PROCESSING
                                   1409 *  CAN CONTINUE
0C1224                             1410 PCANC    EQU   *                    (PROCESSING CAN CONTINUE)
0C1224 9207 23FC      C3AF0        1411          MVI   STRATEGY,X'07'       SET STRATEGY = 7
0C1228 5040 21CC            03800  1412          ST    4,QIQ                STORE ADDR Q(4) IN QIQ
0C122C 58F0 2C44            03744  1413          L     15,ASRPQCST          CALL SRPQCST
00123C 05EF                        1414          BALR  14,15                ''
0C1232 9501 23F1      C3AF1        1415          CLI   PTPQF,X'01'          WERE ANY PQ'S FOUND
0C1236 4770 C138            008F8  1416          BNE   ZONOUTQ4             IF NOT, GO TO ZONOUTQ4
0C123A D503 2104 2108 C3804 03808  1417          CLC   COSTCMP1(4),COSTCMP2  COMPARE COST BUILDING A PP AT THE
                                   1418 *                                   NEW SITE WITH COST USING Q(4) AS AN
                                   1419 *                                   INTERMEDIATE POINT
0C124C 474C C74C            0120C  1420          BL    EWPP                 IF COST USING PP AT NEW SITE IS
                                   1421 *                                   LOWER, GO TO EWPP
                                   1422 *  OTHERWISE, ESTABLISH NEW Q AS A Q USING Q(4) AS AN INTERMEDIATE PT
001244 47F0 C232            00CF2  1423          B     EQWWUIP              GO TO EQWWUIP
                                   1424 *  AT THIS POINT, Q(4) WAS BEING USED AS AN INTERMEDIATE POINT
001248                             1425 Q4UAIP   EQU   *                    (Q(4) USED AS AN INTER POINT)
001248 9101 4C04      C0004        1426          TM    4(4),X'01'           CAN PROCESSING CONTINUE
00124C 4780 C7A0            01260  1427          BZ    Q4IPPCNC             IF NOT, GO TO Q4IPPCNC
                                   1428 *  AT THIS POINT, PROCESSING CAN CONTINUE - IT WILL REMAIN AS AN IP
00125C 9102 4005      C0005        1429          TM    5(4),X'02'           WAS IT BEING QUARRIED
0C1254 4780 C116            00806  1430          BZ    UPDTR4               IF NOT, GO TO UPDTR4
0C1258 94FC 4005      C0005        1431          NI    5(4),B'11111101'     SET Q INDICATOR TO 0
0C125C 47FC C288            00D48  1432          B     PRINTIPM             GO TO PRINTIPM
0C126C 786C C988            01448  1433 Q4IPPCNC LE    6,=X'46FFFFFF'       SET FLT PT REG6 = LARGE NO
001264 D203 C8C8 2060 01388 03760  1434          MVC   ASDUIP(4),MINONE     SET ASDUIP = -1
0C126A 1888                        1435          SR    8,8                  CLEAR REG8
0C126C 5080 C8C4            01384  1436          ST    8,SUMAMT             SET SUM AMOUNT = 0
001270 D203 2084 2088 03784 03788  1437          MVC   POINT2(4),WGCPSG     SET POINT 2 = WGCPSG
001278 5898 C890            01350  1438 PCNCLP   L     9,UIPCHAIN(8)        LOAD REG9 WITH ADDR PQ THAT USES AN
                                   1439 *                                   INTERMEDIATE POINT
00127A 1299                        1440          LTR   9,9                  IS ADDR NEGATIVE
0C127C 4740 C7FC            0128C  1441          BM    WEREAF               IF YES, GO TO WEREAF
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                        F01AUG68   5/30/69

001280 D203 2080 9CCC 03780 00000  1442          MVC   POINT1(4),0(9)      SET POINT1 TO ADDR PQ(9)
0C1286 58F0 2C34            03734  1443          L     15,ASRDIST          FIND DISTANCE PQ(9) TO WGCPSG
0C128A 05EF                        1444          BALR  14,15               ''
0C128C 7820 20A4            037A4  1445          LE    2,DISTX             STORE DIST IN FLT PT REG2
00129C 3962                        1446          CER   6,2                 IS DISTANCE SHORTER THAN PREV SHORT
001292 4740 C7DC            0129C  1447          BL    ARL                 IF NOT, GO TO ARL
0C1296 509C C8C8            01388  1448          ST    9,ASDUIP            STORE ITS ADDR IN ASDUIP
00129A 3862                        1449          LER   6,2                 STORE NEW SHORT DIST IN FLT PT REG6
0C129C 5870 C8C4            01384  1450 ARL      L     7,SUMAMT            LOAD REG7 WITH SUM AMOUNTS
0C12AC 5A70 9008            00008  1451          A     7,8(0,9)            ADD REMAINING LIFE Q(9) TO SUMAMT
0C12A4 5070 C8C4            01384  1452          ST    7,SUMAMT            STORE UPDATED SUM
0012A8 4180 8004            0C004  1453          LA    8,4(0,8)            ADD 4 TO INDEX REG8
0C12AC 47FC C7B6            01276  1454          B     PCNCLP              GO TO PCNCLP
0012BC 5890 C8C8            01388  1455 WEREAF   L     9,ASDUIP            LOAD ADDR CLOSEST Q USING AN IP
                                   1456 *                                  INTO REG9
0012B4 1299                        1457          LTR   9,9                 WERE ANY Q'S FOUND
0C12B6 474C C736            011F6  1458          BM    Q4PCNCO             IF NOT GO TO Q4PCNCO
                                   1459 *  AT THIS POINT THERE IS AT LEAST 1 QUARRY REQUIRING AN INTER PT.
                                   1460 *  ITS ADDR(OR THE ADDR OF THE Q REQUIRING AN IP CLOSEST TO THE WGC)
                                   1461 *  IS IN ASDUIP
0C12BA 1866                        1462          SR    6,6                 CLEAR REG6
0C12BC 5870 901C            00010  1463          L     7,16(0,9)           LOAD ESTAB COST INTO REG7
0C12CC 5C60 20CC            037CC  1464          M     6,AOEPP             MULTIPLY BY ALLOWANCE ON PP IN Q(4)
0C12C4 5D60 C984            01444  1465          D     6,=F'10'            AND DIVIDE BY 10
0012C8 5860 901C            00010  1466          L     6,16(0,9)           LOAD EST COST INTO REG6
0C12CC 1867                        1467          SR    6,7                 SUBTRACT SAVINGS
0C12CE 1876                        1468          LR    7,6                 LOAD UPDATED EST COST INTO REG7
0C12CC 1866                        1469          SR    6,6                 CLEAR REG6
0C12D2 5C60 214C            03840  1470          M     6,HUNDRED           CONVERT EST COST TO PENNIES
0C12D6 5D60 C8C4            01384  1471          D     6,SUMAMT            DIVIDE BY SUM AMOUNTS IN AL Q'S
                                   1472 *                                  USING AN IP
0C12CA 4070 902E            0002E  1473          STH   7,46(0,9)           STORE AMORTIZATION COST IN Q(9)
CC12DE 925B 9005      C0005        1474          MVI   5(9),B'01011011'    SET Q9 TO AN INTER POINT
0C12E2 9211 22C8      039C8        1475          MVI   CARCONT,X'11'       SET CARRIAGE CONTROL CHARACTER
0C12E6 D219 22DC 249E C39DD 0389E  1476          MVC   OUTLINE+20(26),M42  MOVE MESSAGE TO OUTPUT FIELD
0C12EC 4889 CCCC            0CCC0  1477          LH    11,0(9)             LOAD REG11 WITH ROW Q(9)
0C12FC 4EBC 2CCC            03700  1478          CVD   11,DW               CONVERT TO DECIMAL
0C12F4 DE03 22EC 2006 039EC 037C6  1479          ED    OUTLINE+35(4),DW+6  EDIT ROW
0C12FA 48B9 CC02            0C002  1480          LH    11,2(9)             LOAD REG11 WITH COLUMN Q(9)
0C12FE 4EBC 2CCC            037C0  1481          CVD   11,DW               CONVERT TO DECIMAL
0C13C2 DEC3 22F2 2C06 039F2 03706  1482          ED    OUTLINE+41(4),DW+6  EDIT COLUMN
0013C8 D243 22F7 C8DC C39F7 01390  1483          MVC   OUTLINE+46(L'M43),M43
0C13CE 58FC 204C            0374C  1484          L     15,ALINEOUT         CALL OUTPUT ROUTINE
CC1312 05EF                        1485          BALR  14,15               ''
001314 47FC C138            008F8  1486          B     ZONOUTQ4            GO TO ZONOUTQ4
0C1318 CCC01324                    1487 AIPCHAIN DC    A(IPCHAIN)
0C131C CCC0135C                    1488 AUIPCH   DC    A(UIPCHAIN)
CC132C                             1489 IPCOUNT  DS    X
0C1321                             1490 UIPCOUNT DS    X
0C1322 FF                          1491          DC    X'FF'
0C1323 FF                          1492          DC    X'FF'
0C1324                             1493 IPCHAIN  DS    11F
0C135C                             1494 UIPCHAIN DS    11F
00137C                             1495 DIPTWGC  DS    F
00138C                             1496 CLOSIP   DS    F
0C1384                             1497 SUMAMT   DS    F
CC1388                             1498 ASDUIP   DS    F
0C138C                             1499 AMORTCS  DS    H
0C138E                             1500 LAMORTCS DS    H
                                   1501 M43      DC    C'NOW HAS A PROCESSING PLANT AND WILL BE USED AS AN INTEX
0C139C D5D6E640C8C1E240                                RMEDIATE POINT'
0C13D4 C1E240C140D9C5E2            1502 H1       DC    C'AS A RESULT OF ACTIVITIES OF THE PREVIOUS YEAR, THE'
0C14C7 C6D6D3D3D6E6C9D5            1503 H2       DC    C'FOLLOWING CHANGES ARE MADE IN THE GRID CONFIGURATION'
0C144C                             1504          LTORG
0C144C CCCCCCCC                    1505                =F'0'
0C1444 CCCCCCCA                    1506                =F'10'
0C1448 46FFFFFF                    1507                =X'46FFFFFF'
                                   1508 ******************************************************************
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                      F01AUG68   5/30/69

0C145C                             1510 MINEDP   CSECT                      (DATA PROCESSING SECTION)
                                   1511          ENTRY SRFLCQ
0C145C                             1512          USING *,12
0C145C 18CF                        1513          LR    12,15
0C37CC                             1514          USING COMMON,2
0C1452 1B77                        1515          SR    7,7                  CLEAR REG7
0C1454 507C 219C            0389C  1516          ST    7,YCPSG              SET YEAR COST PSG =0
0C1458 507C 21AC            038A0  1517          ST    7,YCUPSG                  ''       UPSG =0
0C145C 5070 21A4            038A4  1518          ST    7,YCCS                    ''       CS =0
0C146C 507C 21A8            038A8  1519          ST    7,YTMPSG             SET YEAR TON-MILES PSG =0
0C1464 507C 21AC            038AC  1520          ST    7,YTMUPSG                      ''       UPSG =0
0C1468 5070 21BC            038B0  1521          ST    7,YTMCS                        ''       CS =0
0C146C 507C 21B4            038B4  1522          ST    7,YTPSG              SET YEAR TONS PSG =0
0C147C 507C 21B8            038B8  1523          ST    7,YTUPSG                  ''       UPSG
0C1474 5070 21BC            038BC  1524          ST    7,YTCS                    ''       CS =0
0C1478 507C 21CC            038C0  1525          ST    7,YTRCST             SET YEAR TRANSPORTATION COST =0
CC147C 5C7C 21C4            038C4  1526          ST    7,YTONSOUT           SET OUTSIDE TONAGE =0
0C148C 5C70 21C8            038C8  1527          ST    7,YCOUTS
0C1484 92CC C484      018D4        1528          MVI   CHANI,X'00'          SET CHANI = 0 (WIP CHAIN)
0C1488 585C 2C7C            03770  1529          L     5,SWIPCH             LOAD REG5 WITH START WIP CHAIN
0C148C                             1530 BEGUSE   EQU   *
0C148C 1255                        1531          LTR   5,5                  ARE WE DONE WITH WIP'S
CC148E 474C CC4C            0149C  1532          BM    GTDEVCH              IF YES, GO TO GTDEVCH
0C1492 D203 C44C 503C 01890 0003C  1533          MVC   NEXTWIP(4),60(5)     OTHERWISE, STORE ADDR NEXT WIP IN CH
0C1498 47FC C08C            014DC  1534          B     CONTWIP              AND GO TO CONTWIP
0C149C                             1535 GTDEVCH  EQU   *
                                   1536 *  AT THIS POINT WE ARE DONE WITH WIP CHAIN.  WE MIUST NOW INVESTIGATE
                                   1537 *  AL DEVFO'S WHICH WILL BECOME WIP'S DURING THE PRESENT YEAR
0C149C 9201 C484      C18D4        1538          MVI   CHANI,X'01'          SET CHAIN I = 1 (DEVFO CHAIN)
0C14AC 585C 2C6C            0376C  1539          L     5,SDEVFOCH           LOAD REG5 WITH START DEVFO CHAIN
0C14A4 1255                        1540 DEVLP    LTR   5,5                  ARE WE DONE WITH DEVFO'S
0C14A6 47BC CC6C            01480  1541          BNM   NENDPER             IF NOT, GO TO NENDPER
0C14AA 58FC C434            01884  1542          L     15,VENDPER          OTHERWISE, GO TO ENDPER
0C14AE C7FF                        1543          BR    15                  ''
0C14BC                             1544 NENDPER  EQU   *
CC14BC D2C3 C43C 5C38 C188C 0C038  1545          MVC   NEXTDEV(4),56(5)     SET NEXTDEV = ADDR NEXT DEVFO
0C14B6 D5C0 2272 5C1A C3972 0C01A  1546          CLC   YEAR(1),26(5)        WILL DEVFO START DURING PRESENT YEAR
0C14BC 477C C358            017A8  1547          BNE   UPDEVPTR             IF NOT, GO TO UPDEVPTR
                                   1548 *  AT THIS POINT, DEVFO WILL BECOME A WIP
CC14CC 92C0 5019      CC019        1549          MVI   25(5),X'00'          SET DEVFO INDICATOR = 0
CC14C4 92C1 5C2B      CC02B        1550          MVI   43(5),X'01'          SET WIP INDICATOR = 1
0C14C8 5C5C 2C9C            0379C  1551          ST    5,ADEVTBD            STORE ADDR OF DEVFO TO BE DELETED
CC14CC 58FC 2C2C            0372C  1552          L     15,ASRDDEV           CALL DELETE DEVFO
CC14CC C5EF                        1553          BALR  14,15                ''
0C14C2 505C 2C9C            03790  1554          ST    5,AWIPTBA            STORE ADDR OF WIP TO BE ADDED
CC14C6 58FC 2C2C            03720  1555          L     15,ASRAWIP           CALL SUBROUTINE ADD WIP
CC14CA C5EF                        1556          BALR  14,15                ''
0C14CC                             1557 CONTWIP  EQU   *                    (CONTINUE WIP PROCESSING)
0C14CC 1888                        1558          SR    8,8                  CLEAR REG8
0C14CE 438C 501B            0C01B  1559          IC    8,27(0,5)            INSERT YEARS TO COMPLETION WIP(5)
0C14E2 5C5C 2118            03818  1560          ST    5,WIPBE             STORE WIP(5) IN WIPBE
0C14E6 58FC 2058            03758  1561          L     15,ASRPPU            CALL PRESENT PERIOD USAGE
CC14EA C5EF                        1562          BALR  14,15                ''
CC14EC C68C                        1563          BCTR  8,0                  SUBTRACT 1 FROM YEARS TO COMPLETION
0C14EE 42BC 5C1B            0C01B  1564          STC   8,27(0,5)            STORE UPDATED YEARS TO COMPLETION
0C14F2 1B33                        1565          SR    3,3                  SET INDEX REG3 = 0 (WE ARE INVESTIGA
                                   1566 *                                   TING PROCESSED S&G
0C14F4 5843 5C4C            0C040  1567 USELOOP  L     4,64(3,5)            LOAD REG4 WITH ADDR Q SUPPLIER
0C14F8 593C C4B8            0190B  1568          C     3,=F'0'              ARE WE INVESTIGATING PROCESSED S&G
0C14FC 478C CCCC            01510  1569          BE    WAIPSG               IF SO, GO TO WAIPSG
0C15CC 593C C4BC            0190C  1570          C     3,=F'4'              ARE WE INVESTIGAT UNPROCESSED S&G
0C15C4 478C CCC8            01518  1571          BE    WAIUPSG              IF SO, GO TO WAIUPSG
0C1508 9204 2405      C38C5        1572          MVI   SUPPLIER,X'04'       SET SUPPLIER = 04 = CRUSHED STONE
CC15CC 47FC COCC            0151C  1573          B     DWAEY                GO TO DWAEY
0C151C 9201 24C5      C38C5        1574 WAIPSG   MVI   SUPPLIER,X'01'       SET SUPPLIER = 01 = PROCESSED S&G
0C1514 47FC COCC            0151C  1575          B     DWAEY                GO TO DWAEY
0C1518 9202 24C5      C38C5        1576 WAIUPSG  MVI   SUPPLIER,X'02'       SET SUPPLIER = 02 = UNPROCESSED S&G
0C151C 58A3 2128            03828  1577 DWAEY    L     10,PPUPSG(3)         IS ANY MATERIAL BEING USED
0C152C 12AA                        1578          LTR   10,10                ''
0C1522 478C C31E            0176E  1579          BZ    WIPDEVUP             IF NOT, GO TO WIPDEVUP
0C1526 95C1 2272      C3972        1580          CLI   YEAR,X'01'           IS YEAR = 1
0C152A 478C COEE            0153E  1581          BE    IAQAS                IF YES, GO TO IAQAS
0C152E 9501 2267      C3967        1582          CLI   ASSGNQ,X'01'         DO WE ASSIGN Q'S EACH PERIOD
0C1532 478C C1A4            015F4  1583          BE    FINDNQ               IF YES, GO TO FINDNQ
0C1536 9502 2267      C3967        1584          CLI   ASSGNQ,X'02'         DO WE ASSIGN ONLY WHEN A NEW Q HAS
                                   1585 *                                   BEEN ADDED
0C153A 478C C196            015E6  1586          BE    HANQBA               IF SO, GO TO HANQBA
0C153E                             1587 IAQAS    EQU   *
C0153E 1244                        1588          LTR   4,4                  IS A QUARRY ASSIGNED
0C154C 4740 C1A4            015F4  1589          BM    FINDNQ               IF NO Q ASSIGNED, GO TO FINDNQ
0C1544 438C 2405            03805  1590          IC    8,SUPPLIER           INSET SUPPLIER INTO REG8
0C1548 448C C1C4            01554  1591          EX    8,ISMFO              IS ASSGNED Q FROM OUTSIDE
0C154C 471C C3C2            01822  1592          BO    COSTOUT              IF SO, GO TO COSTOUT
0C155C 47FC C108            01558  1593          B     CAOSS                OTHERWISE GO TO CAOSS
0C1554 91C0 5C31      C0031        1594 ISMFO    TM    49(5),X'00'          TEST SUPPLIER
0C1558 9102 4C05      C00C5        1595 CAOSS    TM    5(4),X'02'           IS Q(4) STILL A QUARRY
0C155C 478C C1A4            015F4  1596          BZ    FINDNQ               IF NOT, GO TO FINDNQ
0C156C 588C 4C08            0C008  1597          L     8,8(0,4)             LOAD LIFE Q(4) INTO REG8
0C1564 1288                        1598          LTR   8,8                  IS LIFE GREATER THAN 0
0C1566 47DC C1A4            015F4  1599          BNP   FINDNQ               IF NOT, GO TO FINDNQ
0C156A 9104 4C05      C0005        1600          TM    5(4),X'04'           DOES Q(4) USE AN INTER PT
0C156E 471C C138            01588  1601          BO    IIPOK                IF YES, GO TO IIPOK
0C1572 5880 404C            0C04C  1602          L     8,76(0,4)            LOAD PRESENT MATL BEING USED AT Q(4)
0C1576 5A83 2128            03828  1603          A     8,PPUPSG(3)          ADD PRESENT MATL BEING USED
0C157A 598C 40CC            0C00C  1604          C     8,12(0,4)            DOES PRESENT DEMAND EXCEED MAX YR OU
0C157E 4740 C22C            01670  1605          BL    FIGCOST              IF NOT, GO TO FIGCOST
0C1582 1894                        1606          LR    9,4
CC1584 47F0 C15A            015AA  1607          B     MAXYOEX              GO TO MAXYOEX
0C1588 589C 5C5C            00050  1608 IIPOK    L     9,80(0,5)            LOAD ADDR IP BEING USED INTO REG9
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                            F01AUG68   5/30/69

0C158C 1299                        1609          LTR   9,9                 IS THERE AN INTERMEDIATE POINT
0C158E 474C C1A4             015F4 1610          BM    FINDNQ              IF NOT, GO TO FINDNQ
0C1592 9101 9C05       CC0C5       1611          TM    5(9),X'01'          IS INTER PT STILL A PP
001596 478C C1A4             015F4 1612          BZ    FINDNQ              IF NOT, GO TO FINDNQ
0C159A 588C 904C             0C04C 1613          L     8,76(0,9)           LOAD MATL PRESENTLY BEING SUPPLIED
0C159E 5A80 2128             03828 1614          A     8,PPUPSG            ADD PROCESSED S&G REQUIRED
0015A2 598C 9CCC             0CC0C 1615          C     8,12(0,9)           DOES IT EXCEED MAX YR OUTPUT
0C15A6 474C C22C             01670 1616          BL    FIGCOST             IF NOT, GO TO FIGCOST
                                   1617 *  AT THIS POINT, MAXIMUM YEARLY OUTPUT HAS BEEN EXCEEDED
0C15AA                             1618 MAXYOEX  EQU   *                   (MAXIMUM YEARLY OUTPUT EXCEEDED
0015AA 9211 22C8       039C8       1619          MVI   CARCONT,X'11'       SET CARRIAGE CONTROL
0C15AE D219 22EE 24C8 C39EE 03BC8  1620          MVC   OUTLINE+37(26),M35  MOVE MESSAGES TO OUTLINE
0C15B4 D20F 22DD C486 039DD 018D6  1621          MVC   OUTLINE+20(L'M1),M1 ''
0C15BA D221 23C8 C496 C3A08 018E6  1622          MVC   OUTLINE+63(L'M2),M2 ''
0C15CC 4889 CCC0             0C000 1623          LH    11,0(9)             LOAD ROW INTO REG11
0C15C4 4EBC 2CCC             037C0 1624          CVD   11,DW               CONVERT ROW TO DECIMAL
0C15C8 DE03 22FD 2CC6 039FD 037C6  1625          ED    OUTLINE+52(4),DW+6  EDIT ROW
0C15CE 4889 CCC2             0C002 1626          LH    11,2(9)             LOAD COL INTO REG11
0C15D2 4EBC 2CCC             037C0 1627          CVD   11,DW               CONVERT TO DECIMAL
0C15C6 DEC3 2303 2CC6 C3AC3 037C6  1628          ED    OUTLINE+58(4),DW+6  EDIT COLUMN
0C15DC 58FC 2C4C             0374C 1629          L     15,ALINEOUT         CALL OUTPUT ROUTINE
0C15EC 05EF                        1630          BALR  14,15               ''
0C15E2 47FC C1A4             015F4 1631          B     FINDNQ              GO TO FINDNQ
0C15E6 5883 211C             0381C 1632 HANQBA   L     8,TYPQASG(3)        HAS A Q BEEN ADDED
0C15EA 1288                        1633          LTR   8,8                 IS ADDR POSITIVE
0C15EC 472C C1A4             015F4 1634          BP    FINDNQ              IF SO, A Q HAS BEEN ADDED.. GO TO
                                   1635 *                                  FINDNQ
0C15FC 47FC C0EE             0153E 1636          B     IAQAS               OTHERWISE, GO TO IAQAS
0C15F4                             1637 FINDNQ   EQU   *                   (FIND A NEW QUARRY)
0C15F4 505C 2118             03818 1638          ST    5,WIPBE             STORE ADDR OF WIP BEING ESTABLISHED
0C15F8 4230 21CC             038CC 1639          STC   3,INDEXT            STORE INDEX 0=PR S&G, 4=UPR S&G 8=CS
0C15FC 58FC 2C5C             0375C 1640          L     15,ASRFLCQ          CALL SUBROUTINE FIND LOW COST Q
0C16CC C5EF                        1641          BALR  14,15               ''
0C16C2 588C 2114             03814 1642          L     8,QASSGNED          LOAD REG8 WITH ASSGNED QUARRY
0C16C6 1848                        1643          LR    4,8                 LOAD Q ASSGNED INTO REG4
0C16C8 5083 5C4C             0C040 1644          ST    8,64(3,5)           STORE ADDR OF ASSIGNED Q
0C16CC D203 5C50 211C CC05C 03810  1645          MVC   80(4,5),ADDRIP      SET ADDRESS OF INTER POINT
0C1612 43BC 24C5             03805 1646          IC    11,SUPPLIER         INSERT SUPPLIER TYPE INTO REG11
0C1616 448C C21C             0166C 1647          EX    11,TOTYPE           IS ASSGNED Q FROM OUTSIDE
0C161A 478C C22C             01670 1648          BZ    FIGCOST             IF NOT, GO TO FIGCOST
0C161E 9211 22C8       039C8       1649          MVI   CARCONT,X'11'       SET CARRIAGE CONTROL
0C1622 D23F 22DD C444 C39DD 01894  1650          MVC   OUTLINE+20(L'QSQP),QSQP SET UP MESSAGE
0C1628 587C 2114             03814 1651          L     7,QASSGNED          ''
0C162C 48BC 7CCC             0C0C0 1652          LH    11,0(0,7)           ''
0C163C 4EBC 2CCC             037C0 1653          CVD   11,DW               ''
0C1634 DE03 22EC 2CC6 C39EC 037C6  1654          ED    OUTLINE+35(4),DW+6  ''
0C163A 48BC 5CCC             0CCC0 1655          LH    11,0(0,5)           ''
0C163E 4EBC 2CCC             037C0 1656          CVD   11,DW               ''
0C1642 DEC3 2312 2CC6 C3A12 037C6  1657          ED    OUTLINE+73(4),DW+6  ''
0C1648 48BC 5CC2             0CCC2 1658          LH    11,2(0,5)           ''
0C164C 4EBC 2CCC             037C0 1659          CVD   11,DW               ''
0C165C DEC3 2318 2CC6 C3A18 037C6  1660          ED    OUTLINE+79(4),DW+6  ''
0C1656 58FC 2C4C             0374C 1661          L     15,ALINEOUT         ''
CC165A C5EF                        1662          BALR  14,15               ''
0C165C 438C 24C5             03BC5 1663          IC    8,SUPPLIER          INSERT SUPPLIER INTO REG8
0C166C 448C C218             01668 1664          EX    8,IIFOS             SET OUTSIDE Q INDICATOR
0C1664 47FC C3D2             01822 1665          B     COSTOUT             GO TO COSTOUT
CC1668 96CC 5C31       CC031       1666 IIFOS    OI    49(5),X'00'         SET OUTSIDE TYPE
0C166C 91CC 24C6       C3BC6       1667 TOTYPE   TM    OUTSI,X'00'         IS IT FROM OUTSIDE
0C167C                             1668 FIGCOST  EQU   *                   (FIGURE COST)
                                   1669 *  AT THIS POINT THE WIP BEING PROCESSED IS IN REG5. ITS Q SUPPLIER IS
                                   1670 *  IN REG4, AND AN INTERMEDIATE POINT (IF APPLICABLE) IS AT REG5 + 80
0C167C D2CC C485 24C5 C18D5 03B05  1671          MVC   STRATEGI(1),SUPPLIER  SET STRATEGI = SUPPLIER
0C1676 97FF C485       C18D5       1672          XI    STRATEGI,X'FF'      INVERT ALL STRATEGI BITS
0C167A 438C C485             018C5 1673          IC    11,STRATEGI         INSERT STRATEGI INTO REG11
0C167E 448C C354             017A4 1674          EX    11,SOMEZ           SET OUTSIDE INDICATOR = 0
0C1682 5883 501C             0C01C 1675          L     8,28(3,5)           LOAD MATL REQD AT WIP(5) INTO REG8
0C1686 5B83 2128             03828 1676          S     8,PPUPSG(3)         SUBTRACT PRESENT MAT'L USAGE
0C168A 5083 5C1C             0C01C 1677          ST    8,28(3,5)                STORE UPDATED MAT'L REQ'D
0C168E 588C 4CC8             0C008 1678          L     8,8(0,4)            LOAD LIFE Q(4) INTO REG8
0C1692 5B83 2128             03828 1679          S     8,PPUPSG(3)         SUBTRACT MATL BEING USED
0C1696 508C 4CC8             0C0C8 1680          ST    8,8(0,4)            STORE UPDATED LIFE Q(4)
0C169A 5883 2184             038B4 1681          L     8,YTPSG(3)          LOAD YEARLY TONS MATL USED INTO REG8
0C169E 5A83 2128             03828 1682          A     8,PPUPSG(3)         ADD TONS PRESENTLY BEING USED
0C16A2 5083 2184             038B4 1683          ST    8,YTPSG(3)          STORE UPDATED TONS
0C16A6 1233                        1684          LTR   3,3                 IS REG3 0 (ARE WE TESTING PROCESSED
                                   1685 *                                  S&G
0C16A8 4770 C28C             016DC 1686          BNZ   NOIP                IF NOT, GO TO NOIP
                                   1687 *  AT THIS POINT, WE ARE INVESTIGATING PROCESSED S&G
0C16AC 589C 4C08             0C008 1688          L     9,8(0,4)            LOAD LIFE Q(4) INTO REG9
0C16BC 5A9C 2128             03828 1689          A     9,PPUPSG            ADD MATL BEING USED
0C16B4 1888                        1690          SR    8,8                 CLEAR REG8
0C16B6 1BAA                        1691          SR    10,10               CLEAR REG10
0C16B8 43AC 4018             0C018 1692          IC    10,24(0,4)          INSERT PERCENT SAND INTO REG10
0C16BC 1C8A                        1693          MR    8,10                MULTIPLY BY PERCENT SAND AND
0C16BE 5D8C 214C             03840 1694          D     8,HUNDRED           DIVIDE BY 100 = AMT SAND AT Q(4)
0C16C2 5B9C 2134             03834 1695          S     9,PPUSAND           SUBTRACT PREST PERIOD SAND = SAND
                                   1696 *                                  AFTER PRESENT DEMAND
0C16C6 1B88                        1697          SR    8,8                 CLEAR REG8
0C16C8 5C8C 214C             03840 1698          M     8,HUNDRED           MULTIPLY SAND BY 100 AND
0C16CC 5D8C 40C8             0C008 1699          D     8,8(0,4)            DIVIDE BY LIFE AFTER = PERCENT
                                   1700 *                                  SAND AFTER
0C16DC 429C 4C18             00018 1701          STC   9,24(0,4)           STORE UPDATED PERCENT SAND
0C16D4 91C4 4CC5       CC005       1702          TM    5(4),X'04'          DOES Q(4) USE AN INTER POINT
0C16D8 4710 C36C             017BC 1703          BO    YESIP               IF YES, GO TO YESIP
0C16DC                             1704 NOIP     EQU   *                   (NO INTERMEDIATE POINT)
0C16DC 5860 404C             0C04C 1705          L     6,76(0,4)           LOAD REG6 WITH PRESENT USAGE
0C16EC 5A63 2128             03828 1706          A     6,PPUPSG(3)         ADD PRESENT PERIOD USAGE
0C16E4 5060 4C4C             0C04C 1707          ST    6,76(0,4)           STORE PRESENT DEMAND
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2 STMT   SOURCE STATEMENT                                       F01AUG68   5/30/69

0016E8 1866                       1708          SR    6,6                  CLEAR REG6
0016EA 4870 402E            0002E 1709          LH    7,46(0,4)            LOAD AMORT COST INTO REG7
0016EE 5C60 2128            03828 1710          M     6,PPUPSG             MULTIPLY BY MATL USED
0C16F2 5D60 214C            03840 1711          D     6,HUNDRED            DIVIDE BY 100 TO CONVERT TO DOLLARS
0016F6 1887                       1712          LR    8,7                  LOAD INTO REG8
0016F8 D203 20B0 4CCC 03780 00000 1713          MVC   POINT1(4),0(4)       SET POINT 1 TO Q(4)
0016FE D203 2084 5CCC 03784 0CCC0 1714          MVC   POINT2(4),0(5)       SET POINT 2 = WIP(5)
0C17C4 58FC 2C34            03734 1715          L     15,ASRDIST           FIND DISTANCE WIP(5) TO Q(4)
0C17C8 C5EF                       1716          BALR  14,15                ''
0C17CA D203 20C4 20A4 037C4 037A4 1717          MVC   TRANSD(4),DISTX
0C171C 58F0 2C38            03738 1718          L     15,ASRTRCST          FIND TRANSPORTATION COST
0C1714 05EF                       1719          BALR  14,15                ''
                                  1720 *  AT THIS POINT DISTX = TRANSPORTATION COST IN FLT POINT AND
                                  1721 *  FIXPTCST = TRANSPORTATION COST (IN FIXED POINT) IN PENNIES/TON
0C1716 782C 20A4            037A4 1722 CDTFP    LE    2,DISTX              CONVERT DISTANCE TO FIXED POINT
0C171A 7E2C C4C0            01910 1723          AU    2,=X'46000000'       ''
0C171E 702C C438            01888 1724          STE   2,DISTFIX            ''
0C1722 92CC C438      C1888       1725          MVI   DISTFIX,X'00'        ''
0C1726 1866                       1726          SR    6,6                  CLEAR REG6
0C1728 587C C438            01888 1727          L     7,DISTFIX            LOAD DISTANCE INTO REG7
0C172C 5C63 2128            03828 1728          M     6,PPUPSG(3)          MULTIPLY BY PRESENT USAGE
0C173C 5893 21A8            038A8 1729          L     9,YTMPSG(3)          LOAD REG9 WITH YEARLY TON -MILES
0C1734 1A97                       1730          AR    9,7                  ADD PRESENT TON-MILES
0C1736 5093 21A8            038A8 1731          ST    9,YTMPSG(3)          STORE UPDATED TON-MILES
0C173A 1866                       1732          SR    6,6                  CLEAR REG6
0C173C 5870 20C8            037C8 1733          L     7,FIXPTCST           LOAD TRANS COST INTO REG7
0C174C 5C63 2128            03828 1734          M     6,PPUPSG(3)          MULTIPLY BY PRESENT USAGE
0C1744 5D60 214C            03840 1735          D     6,HUNDRED            DIVIDE BY 100 TO CONVERT TO DOLLARS
0C174E 589C 21CC            038C0 1736          L     9,YTRCST             LOAD REG9 WITH YEARLY TRANSPORTATION
                                  1737 *                                   COST
CC174C 1A97                       1738          AR    9,7                  ADD PRESENT TRANSPORTATION COST
0C174E 5C9C 21CC            038C0 1739          ST    9,YTRCST             STORE UPDATED TRANSPORTATION COST
001752 1A87                       1740          AR    8,7                  ADD TRANSPORTATION COST TO REG8
0C1754 1866                       1741          SR    6,6                  CLEAR REG6
0C1756 487C 4C14            0C014 1742          LH    7,20(0,4)            LOAD COST TO MINE & PROCESS INTO 7
0C175A 5C63 2128            03828 1743          M     6,PPUPSG(3)          MULTIPLY BY PRESENT USAGE
0C175E 5D6C 214C            03840 1744          D     6,HUNDRED            DIVIDE BY 100 TO CONVERT TO DOLLARS
0C1762 1A87                       1745          AR    8,7                  ADD TO REG 8
0C1764 5873 219C            0389C 1746          L     7,YCPSG(3)           LOAD YEARLY TOTAL COST INTO REG7
0C1768 1A78                       1747          AR    7,8                  ADD PRESENT TOTAL COST
0C176A 5073 219C            0389C 1748          ST    7,YCPSG(3)           UPDATE YEARLY COST
00176E 413C 3CC4            0CCC4 1749 WIPDEVUP LA    3,4(0,3)             ADD 4 TO INDEX REG3
0C1772 593C C4C4            01914 1750          C     3,=F'8'              IS REG3 GREATER THAN 8
0C1776 47DC C0A4            014F4 1751          BNH   USELOOP              IF NOT, GO TO USELOOP
0C177A 1888                       1752          SR    8,8                  CLEAR REG8
0C177C 438C 5C18            0C018 1753          IC    8,27(0,5)            LOAD YEARS TO COMPLETION INTO REG8
0C178C 1288                       1754          LTR   8,8                  IS WIP COMPLETED
0C1782 477C C344            01794 1755          BNZ   CLWAI                IF NOT, GO TO CLWAI
                                  1756 *  AT THIS POINT, WIP IN REG5 HAS BEEN COMPLETED
0C1786 92CC 502B      CC02B       1757          MVI   43(5),X'00'          SET WIP INDICATOR TO 0
0C178A 505C 2CAC            037A0 1758          ST    5,AWIPTBD            STORE ADDR OF WIP TO BE DELETED
0C178E 58FC 2C3C            03730 1759          L     15,ASRDWIP          CALL SUBROUTINE DELETE WIP
0C1792 C5EF                       1760          BALR  14,15                ''
0C1794                            1761 CLWAI    EQU   *                    (CHECK WHICH CHAIN WE ARE IN)
0C1794 95CC C484      C18D4       1762          CLI   CHANI,X'00'          ARE WE IN WIP CHAIN
0C1798 477C C358            017A8 1763          BNE   UPDEVPTR             IF NOT, GO TO UPDEVPTR
                                  1764 *   AT THIS POINT, WE ARE IN WIP CHAIN
0C179C 585C C440            01890 1765          L     5,NEXTWIP            LOAD REG5 WITH ADDR NEXT WIP IN CHAI
0C17AC 47FC CC3C            0148C 1766          B     BEGUSE               GO TO BEGUSE
0C17A4 94CC 5031      CC031       1767 SOMEZ    NI    49(5),X'00'          SET OUTSIDE INDICATOR BIT = 0
0C17A8 585C C43C            0188C 1768 UPDEVPTR L     5,NEXTDEV            LOAD REG5 WITH ADDR NEXT DEVFO IN CH
0C17AC 47FC CC54            014A4 1769          B     DEVLP                GO TO DEVLP
                                  1770 *  AT THIS POINT AN INTERMEDIATE POINT IS BEING USED
0C178C                            1771 YESIP    EQU   *                    (YES, AN INTER POINT)
0C178C 5890 5C5C            0C050 1772          L     9,80(0,5)            LOAD REG9 WITH ADDR INTER POINT
0C1784 586C 9C4C            0C04C 1773          L     6,76(0,9)            LOAD REG6 WITH USAGE Q(9)
0C178E 5A6C 2128            03828 1774          A     6,PPUPSG             ADD PRESENT USAGE
0C178C 506C 9C4C            0C04C 1775          ST    6,76(0,9)            STORE UPDATED USAGE
0C17CC 1866                       1776          SR    6,6                  CLEAR REG6
0C17C2 4870 9C2E            0002E 1777          LH    7,46(0,9)            LOAD AMORTIZATION COST OF IP(9)
                                  1778 *                                   INTO REG 7
0C17C6 5C6C 2128            03828 1779          M     6,PPUPSG             MULTIPLY BY USAGE PROCESSED S&G
0C17CA 5D6C 214C            03840 1780          D     6,HUNDRED            AND DIVIDE BY 100 TO CONVERT TO $
0C17CE 1887                       1781          LR    8,7                  LOAD IMTO REG8
0C17DC D203 20BC 4CCC 037B0 0CCC0 1782          MVC   POINT1(4),0(4)       SET POINT1 = Q(4)
0C17C6 D203 2CB4 9CCC C37B4 0CCC0 1783          MVC   POINT2(4),0(9)       SET POINT2 = Q(9)
0017DC 58FC 2C34            03734 1784          L     15,ASRDIST           FIND DISTANCE Q(4) TO Q(9)
0C17EC C5EF                       1785          BALR  14,15
0C17E2 7820 2CA4            037A4 1786          LE    2,DISTX              LOAD FLT PT REG2 WITH DISTX
0017E6 D203 2CC4 20A4 037C4 037A4 1787          MVC   TRANSD(4),DISTX      FIND TRANSPORTATION COST
0C17EC 58FC 2038            03738 1788          L     15,ASRTRCST          ''
0017FC 05EF                       1789          BALR  14,15                ''
0C17F2 58A0 2CC8            037C8 1790          L     10,FIXPTCST          LOAD TRANS COST INTO REG10
0C17F6 D203 2C80 5CC0 03780 00000 1791          MVC   POINT1(4),0(5)       FIND DISTANCE Q(9) TO WIP(5)
0C17FC 58F0 2034            03734 1792          L     15,ASRDIST           ''
0018CC 05EF                       1793          BALR  14,15                ''
0018C2 7A2C 2CA4            037A4 1794          AE    2,DISTX              ADD TO FLT PT REG2 = TOTAL DISTANCE
0C18C6 D203 20C4 20A4 C37C4 037A4 1795          MVC   TRANSD(4),DISTX      FIND TRANS COST Q(9) TO WIP(5)
0C18CC 702C 20A4            037A4 1796          STE   2,DISTX              SET DISTX = DIST Q(4) TO Q(9) +
                                  1797 *                                   Q(9) TO WIP(5)
0C181C 58F0 2038            03738 1798          L     15,ASRTRCST          FIND TRANSPORTATION COST
001814 05EF                       1799          BALR  14,15                ''
0C1816 5AAC 2CC8            037C8 1800          A     10,FIXPTCST          ADD TRANSPORTATION COST TO REG10
0C181A 50AC 2CC8            037C8 1801          ST    10,FIXPTCST          STORE TOTAL TRANSPORTATION COST
0C181E 47F0 C2C6            01716 1802          B     CDTFP                GO TO CDTFP
0C1822                            1803 COSTOUT  EQU   *                    (COST FORM OUTSIDE ROUTINE)
0C1822 5883 501C            0001C 1804          L     8,28(3,5)            UPDATE LIFE AT WIP(5)
0C1826 5B83 2128            03828 1805          S     8,PPUPSG(3)          ''
0C182A 5083 5C1C            0C01C 1806          ST    8,28(3,5)            ''
```

```
  LOC  OBJECT CODE     ADDR1 ADDR2  STMT   SOURCE STATEMENT                                              F01AUG68   5/30/69

00182E 588C 40CC             0000C  1807            L     8,12(0,4)             UPDATE MATERIAL BEING USED AT OUTSID
001832 5A83 2128             03828  1808            A     8,PPUPSG(3)           ''
001836 5080 40CC             0000C  1809            ST    8,12(0,4)             ''
00183A 5880 21C4             038C4  1810            L     8,YTONSOUT            UPDATE YEARLY TONS FROM OUTSIDE
00183E 5A83 2128             03828  1811            A     8,PPUPSG(3)           ''
001842 508C 21C4             038C4  1812            ST    8,YTONSOUT            ''
001846 D203 2C80 5CCC C3780 0C000  1813            MVC   POINT1(4),0(5)        SET POINT1 = WIP(5)
00184C D203 2CB4 4CC6 03784 00006  1814            MVC   POINT2(4),6(4)       SET POINT2 = UNLD PT OUTSIDE Q(4)
001852 58F0 2C34             03734  1815            L     15,ASRDIST            FIND DISTANCE
001856 05EF                         1816            BALR  14,15                 ''
001858 D203 20C4 20A4 037C4 037A4  1817            MVC   TRANSD(4),DISTX
00185E 58F0 2038             03738  1818            L     15,ASRTRCST           FIND TRANSPORTATION COST
001862 05EF                         1819            BALR  14,15
001864 589C 20C8             037C8  1820            L     9,FIXPTCST            LOAD TRANS COST INTO REG9
001868 4A9C 4004             0C004  1821            AH    9,4(0,4)              ADD TOTAL COST TO UNLD PT
00186C 1888                         1822            SR    8,8                   CLEAR REG8
00186E 5C83 2128             03828  1823            M     8,PPUPSG(3)           MULTIPLY BY MATL USED
001872 5D8C 214C             03840  1824            D     8,HUNDRED             DIVIDE BY 100 TO CONVERT TO DOLLARS
001876 587C 21C8             038C8  1825            L     7,YCOUTS              UPDATE TOTAL COST FROM OUTSIDE
00187A 1A79                         1826            AR    7,9                   ''
00187C 5070 21C8             038C8  1827            ST    7,YCOUTS              ''
00188C 47FC C31E             0176E  1828            B     WIPDEVUP              GO TO WIPDEVUP
001884 CCCC1918                     1829 VENDPER    DC    A(ENDPER)
001888                              1830 DISTFIX    DS    F
00188C                              1831 NEXTDEV    DS    F
00189C                              1832 NEXTWIP    DS    F
                                    1833 QSQP       DC    C'OUTSIDE QUARRY  -/- HAS BEEN ASSIGNED TO WIP IN GRID  X
001894 D6E4E3E2C9C4C54C                                   --/,  -/-.'
0018C4                              1834 CHANI      DS    X
0018C5                              1835 STRATEGI   DS    X
0018C6 E8C5C1D9D3E840C4             1836 M1         DC    C'YEARLY DEMAND ON'
0018E6 C8C1E240C5E7C3C5             1837 M2         DC    C'HAS EXCEEDED MAXIMUM YEARLY OUTPUT'
0019C8                              1838            LTORG
0019C8 CCCCCCCC                     1839                  =F'0'
0019CC CCCCCC04                     1840                  =F'4'
00191C 46CCCCCC                     1841                  =X'46000000'
001914 CCCCCC08                     1842                  =F'8'
001918                              1843 ENDPER     EQU   *                     (END PERIOD)
001918                              1844            USING *,12
001918 18CF                         1845            LR    12,15
00191A 9288 22C8       C39C8        1846            MVI   CARCONT,X'88'         SKIP TO TOP OF PAGE
00191F 58FC 204C             0374C  1847            L     15,ALINEOUT           ''
001922 05EF                         1848            BALR  14,15       ''
001924 9211 22C8       C39C8        1849            MVI   CARCONT,X'11'         WRITE OUTPUT HEADINGS
001928 D209 22F9 CA67 039F9 0237F  1850            MVC   OUTLINE+48(10),M300    ''
00192E D207 2304 254B C3AC4 03C4B  1851            MVC   OUTLINE+59(8),BYM+6 ''
001934 1877                         1852            SR    7,7                   ''
001936 437C 2272             03972  1853            IC    7,YEAR                WRITE YEAR
00193A 4E7C 2CCC             03700  1854            CVD   7,DW                    ''
00193E DEC3 23C8 2CC6 C3A08 037C6  1855            ED    OUTLINE+63(4),DW+6      ''
001944 58FC 204C             0374C  1856            L     15,ALINEOUT             ''
001948 C5EF                         1857            BALR  14,15                   ''
00194A D20C 22E7 CA71 039E7 02389  1858            MVC   OUTLINE+30(13),M301     WRITE HEADINGS
00195C D20E 22F8 CA7E C39F8 02396  1859            MVC   OUTLINE+50(15),M302     ''
001956 D20C 2311 CA8D C3A11 023A5  1860            MVC   OUTLINE+72(13),M303     ''
00195C 58FC 204C             0374C  1861            L     15,ALINEOUT             ''
00196C C5EF                         1862            BALR  14,15                   ''
001962 D204 22D4 CA56 039D4 0236E  1863            MVC   OUTLINE+11(5),M298      ''
001968 C206 22DA CA9A 039DA 023B2  1864            MVC   OUTLINE+17(7),M304      ''
00196E D20B 22E7 CA5B 039E7 02373  1865            MVC   OUTLINE+30(12),M299     ''
001974 D2CB 22FC CA5B C39FC 02373  1866            MVC   OUTLINE+51(12),M299     ''
00197A D20B 2311 CA5B C3A11 02373  1867            MVC   OUTLINE+72(12),M299     ''
001980 5870 219C             0389C  1868            L     7,YCPSG                 WRITE YEARLY COST PSG
001984 4E7C 2CCC             03700  1869            CVD   7,DW                    ''
001988 DE0B 22E7 2CC3 C39E7 03703  1870            ED    OUTLINE+30(12),DW+3     ''
00198E 5870 21AC             038A0  1871            L     7,YCUPSG                WRITE YEARLY COST UPSG
001992 4E70 2CC0             03700  1872            CVD   7,DW                    ''
001996 DECB 22FC 2CC3 C39FC 03703  1873            ED    OUTLINE+51(12),DW+3     ''
00199C 5870 21A4             038A4  1874            L     7,YCCS                  WRITE YEARLY COST CS
0019AC 4E7C 2CCC             03700  1875            CVD   7,DW                    ''
0019A4 DECB 2311 2CC3 C3A11 03703  1876            ED    OUTLINE+72(12),DW+3     ''
0019AA 58F0 204C             0374C  1877            L     15,ALINEOUT             ''
0019AE C5EF                         1878            BALR  14,15                   ''
0019B0 D204 22D4 CA56 C39D4 0236E  1879            MVC   OUTLINE+11(5),M298      WRITE HEADINGS
0019B6 D208 22DA CAA1 C39DA 02389  1880            MVC   OUTLINE+17(9),M305      ''
0019BC C20B 22E7 CA5B C39E7 02373  1881            MVC   OUTLINE+30(12),M299     ''
0019C2 D20B 22FC CA5B 039FC 02373  1882            MVC   OUTLINE+51(12),M299     ''
0019C8 D20B 2311 CA5B C3A11 02373  1883            MVC   OUTLINE+72(12),M299     ''
0019CE 587C 21A8             038A8  1884            L     7,YTMPSG                WRITE TON-MILES PSG
0019D2 4E70 2CCC             037C0  1885            CVD   7,DW                    ''
0019D6 DE0B 22E7 2CC3 C39E7 03703  1886            ED    OUTLINE+30(12),DW+3     ''
0019DC 5870 21AC             038AC  1887            L     7,YTMUPSG               WRITE TON-MILES UPSG
0019EC 4E70 2CCC             03700  1888            CVD   7,DW                    ''
0019E4 DECB 22FC 2CC3 C39FC 037C3  1889            ED    OUTLINE+51(12),DW+3     ''
0019EA 5870 21B0             038B0  1890            L     7,YTMCS                 WRITE TON-MILES CS
0019EE 4E7C 2CCC             037C0  1891            CVD   7,DW                    ''
0019F2 DE0B 2311 2CC3 C3A11 037C3  1892            ED    OUTLINE+72(12),DW+3     ''
0019F8 58FC 204C             0374C  1893            L     15,ALINEOUT             ''
0019FC C5EF                         1894            BALR  14,15                   ''
0019FE 9219 22C8       039C8        1895            MVI   CARCONT,X'19'
001A02 D204 22D4 CA56 039D4 0236E  1896            MVC   OUTLINE+11(5),M298      WRITE HEADINGS
001AC8 D2C3 22DA CAAA C39DA 023C2  1897            MVC   OUTLINE+17(4),M306      ''
001ACE D20B 22E7 CA5B C39E7 02373  1898            MVC   OUTLINE+30(12),M299     ''
001A14 D20B 22FC CA5B C39FC 02373  1899            MVC   OUTLINE+51(12),M299     ''
001A1A D208 2311 CA5B C3A11 02373  1900            MVC   OUTLINE+72(12),M299     ''
001A2C 5870 21B4             038B4  1901            L     7,YTPSG                 WRITE TONS PSG
001A24 4E70 2CCC             037C0  1902            CVD   7,DW                    ''
001A28 DE0B 22E7 2CC3 C39E7 03703  1903            ED    OUTLINE+30(12),DW+3     ''
001A2E 5870 21B8             038B8  1904            L     7,YTUPSG                WRITE TONS UPSG
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                              F01AUG68  5/30/69

0C1A32 4E70 2C00            037C0  1905            CVD   7,DW                   ''
0C1A36 DECB 22FC 2CC3 039FC 03703  1906            ED    OUTLINE+51(12),DW+3    ''
0C1A3C 5870 21BC            038BC  1907            L     7,YTCS                 WRITE TONS CS
0C1A4C 4E7C 2CCC            037C0  1908            CVD   7,DW                   ''
0C1A44 DE0B 2311 2CC3 C3A11 037C3  1909            ED    OUTLINE+72(12),DW+3    ''
0C1A4A 58FC 2C4C            0374C  1910            L     15,ALINEOUT            ''
0C1A4E 05EF                        1911            BALR  14,15                  ''
0C1A5C 9211 22C8      C39C8        1912            MVI   CARCONT,X'11'
0C1A54 D204 22E2 CA56 039E2 0236E  1913            MVC   OUTLINE+25(5),M298     WRITE TOTALS FOR YEAR
0C1A5A D217 22E8 CAAE C39E8 023C6  1914            MVC   OUTLINE+31(24),M307    ''
0C1A6C D20B 2301 CA5B C3A01 02373  1915            MVC   OUTLINE+56(12),M299    ''
0C1A66 587C 21CC            038C0  1916            L     7,YTRCST               ''
0C1A6A 4E70 2CCC            03700  1917            CVD   7,DW                   ''
0C1A6E DECB 2301 2CC3 C3A01 037C3  1918            FD    OUTLINE+56(12),DW+3    ''
0C1A74 58FC 204C            0374C  1919            L     15,ALINEOUT            ''
0C1A78 05EF                        1920            BALR  14,15                  ''
0C1A7A D204 22E2 CA56 039E2 0236E  1921            MVC   OUTLINE+25(5),M298     ''
0C1A8C D21E 22E8 CAC6 C39E8 023DE  1922            MVC   OUTLINE+31(31),M308    ''
0C1A86 D20B 23C8 CA5B C3A08 02373  1923            MVC   OUTLINE+63(12),M299    ''
0C1A8C 587C 21C4            038C4  1924            L     7,YTONSOUT             ''
0C1A9C 4E7C 2CCC            037C0  1925            CVD   7,DW                   ''
0C1A94 CE0B 2308 2CC3 C3A08 037C3  1926            ED    OUTLINE+63(12),DW+3    ''
0C1A9A 58FC 2C4C            0374C  1927            L     15,ALINEOUT            ''
0C1A9E 05EF                        1928            BALR  14,15                  ''
CC1AAC C2C4 22E2 CA56 C39E2 0236E  1929            MVC   OUTLINE+25(5),M298     ''
0C1AA6 D227 22E8 CAE5 039E8 023FD  1930            MVC   OUTLINE+31(40),M309    ''
0C1AAC C20B 2311 CA5B C3A11 02373  1931            MVC   OUTLINE+72(12),M299    ''
0C1AB2 587C 21C8            038C8  1932            L     7,YCOUTS               ''
CC1AB6 4E7C 2CCC            037C0  1933            CVD   7,DW                   ''
0C1ABA DE0B 2311 2CC3 C3A11 03703  1934            ED    OUTLINE+72(12),DW+3    ''
0C1ACC 58FC 2C4C            0374C  1935            L     15,ALINEOUT            ''
0C1AC4 C5EF                        1936            BALR  14,15                  ''
0C1AC6 D204 22E2 CA56 039E2 0236E  1937            MVC   OUTLINE+25(5),M298     ''
0C1ACC D208 22E8 CBCD C39E8 02425  1938            MVC   OUTLINE+31(9),M310     ''
0C1AC2 C20B 22F2 CA5B C39F2 02373  1939            MVC   OUTLINE+41(12),M299    ''
0C1AC8 587C 219C            0389C  1940            L     7,YCPSG                ''
0C1ADC 5A7C 21AC            038A0  1941            A     7,YCUPSG               ''
0C1AEC 5A7C 21A4            038A4  1942            A     7,YCCS                 ''
0C1AE4 5A7C 21C8            038C8  1943            A     7,YCOUTS               ''
0C1AE8 5C7C CA4C            02358  1944            ST    7,TDOL                 ''
0C1AEC 4E7C 2CCC            03700  1945            CVD   7,DW                   ''
0C1AFC CEC8 22F2 2CC3 C39F2 03703  1946            ED    OUTLINE+41(12),DW+3    ''
CC1AF6 58FC 2C4C            0374C  1947            L     15,ALINEOUT            ''
0C1AFA C5EF                        1948            BALR  14,15                  ''
0C1AFC D204 22E2 CA56 C39F2 0236E  1949            MVC   OUTLINE+25(5),M298     ''
0C1BC2 D224 22E8 CB16 C39F8 0242E  1950            MVC   OUTLINE+31(37),M311    ''
0C1BC8 D20B 23CD CA5B C3ACD 02373  1951            MVC   OUTLINE+68(12),M299    ''
0C1BCE 5870 21A8            038A8  1952            L     7,YTMPSG               ''
0C1B12 5A7C 21AC            038AC  1953            A     7,YTMUPSG              ''
0C1B16 5A70 21BC            038B0  1954            A     7,YTMCS                ''
0C1B1A 5C7C CA44            0235C  1955            ST    7,TTM                  ''
0C1B1E 4E7C 2CCC            037C0  1956            CVD   7,DW                   ''
0C1B22 CECB 230D 2CC3 C3ACD 037C3  1957            ED    OUTLINE+68(12),DW+3    ''
CC1B28 58FC 2C4C            0374C  1958            L     15,ALINEOUT            ''
0C1B2C C5EF                        1959            BALR  14,15                  ''
0C1B2F D204 22E2 CA56 039F2 0236E  1960            MVC   OUTLINE+25(5),M298     ''
0C1B34 D2C5 22E8 CB3B 039E8 02453  1961            MVC   OUTLINE+31(6),M312     ''
CC1B3A D2CB 22EF CA5B C39EF 02373  1962            MVC   OUTLINE+38(12),M299    ''
0C1B4C 587C 21B4            038B4  1963            L     7,YTPSG                ''
0C1B44 5A7C 21B8            038B8  1964            A     7,YTUPSG               ''
0C1B48 5A7C 21BC            038BC  1965            A     7,YTCS                 ''
0C1B4C 5A7C 21C4            038C4  1966            A     7,YTONSOUT             ''
0C1B5C 507C CA3C            02354  1967            ST    7,TT                   ''
0C1B54 4E70 2CCC            037C0  1968            CVD   7,DW                   ''
0C1B58 DE0B 22EF 2CC3 C39EF 03703  1969            ED    OUTLINE+38(12),DW+3    ''
0C1B5E 58FC 2C4C            0374C  1970            L     15,ALINEOUT            ''
0C1B62 05EF                        1971            BALR  14,15                  ''
0C1B64 D204 22E2 CA56 039E2 0236E  1972            MVC   OUTLINE+25(5),M298     ''
0C1B6A D226 22E8 CB41 C39F8 02459  1973            MVC   OUTLINE+31(39),M313    ''
0C1B7C C20B 231C CA5B C3A10 02373  1974            MVC   OUTLINE+71(12),M299    ''
CC1B76 587C 214C            0384C  1975            L     7,MWTD                 ''
0C1B7A 4E7C 2CCC            037C0  1976            CVD   7,DW                   ''
0C1B7E DECB 231C 2CC3 C3A10 03703  1977            FD    OUTLINE+71(12),DW+3    ''
0C1B84 58FC 204C            0374C  1978            L     15,ALINEOUT            ''
CC1B88 C5EF                        1979            BALR  14,15                  ''
0C1B8A D204 22E2 CA56 C39E2 0236E  198C            MVC   OUTLINE+25(5),M298     ''
CC1B9C D22C 22E8 CB68 C39F8 02480  1981            MVC   OUTLINE+31(45),M314    ''
0C1B96 D20B 2315 CA5B C3A15 02373  1982            MVC   OUTLINE+76(12),M299    ''
0C1B9C 5870 2150            03850  1983            L     7,MWTDPQ               ''
0C1BAC 4E70 2CCC            037C0  1984            CVD   7,DW                   ''
0C1BA4 DE0B 2315 2CC3 C3A15 037C3  1985            ED    OUTLINE+76(12),DW+3    ''
001BAA 58F0 204C            0374C  1986            L     15,ALINEOUT            ''
0C1BAE C5EF                        1987            BALR  14,15                  ''
                                   1988 ** THE NEXT SECTION ACCUNULATES ALL YEARLY FIGURES AND WRITES
                                   1989 ** CUMULATIVE DATA TO DATE
001B8C 9289 22C8      C39C8        1990            MVI   CARCONT,X'89'
0C1B84 D204 22E2 CA56 039E2 0236E  1991            MVC   OUTLINE+25(5),M298
0C1B8A D21C 22E8 CB95 C39E8 024AD  1992            MVC   OUTLINE+31(17),M315
0C1BCC D20B 22FA CA5B 039FA 02373  1993            MVC   OUTLINE+49(12),M299
0C1BC6 5870 214C            0384C  1994            L     7,MWTD                            MATERIAL WASTED TO DATE
0C1BCA 5A70 2150            03850  1995            A     7,MWTDPQ
0C1BCE 4E7C 2CCC            03700  1996            CVD   7,DW
001BD2 DE0B 22FA 2CC3 C39FA 037C3  1997            ED    OUTLINE+49(12),DW+3
0C1BC8 58F0 204C            0374C  1998            L     15,ALINEOUT
0C1BDC C5EF                        1999            BALR  14,15
0C1BDE 9211 22C8      039C8        2000            MVI   CARCONT,X'11'
0C1BE2 D224 22DE CBA6 039DE 024BE  2001            MVC   OUTLINE+21(37),M316
0C1BE8 D207 2304 254B C3A04 03C4B  2002            MVC   OUTLINE+59(8),BYM+6
0C1BEE 1B77                        2003            SR    7,7
```

```
  LOC  OBJECT CODE     ADDR1 ADDR2  STMT   SOURCE STATEMENT                                                    F01AUG68  5/30/69

0C1BFC 4370 2272             03972  2004              IC    7,YEAR
0C1BF4 4E7C 2CCC             037C0  2005              CVD   7,DW
0C1BF8 DE03 2308 2CC6 03AC8 03706  2006              ED    OUTLINE+63(4),DW+6
0C1BFE 58FC 204C             0374C  2007              L     15,ALINEOUT
0C1CC2 05EF                         2008              BALR  14,15
0C1CC4 D20C 22E7 CA71 039E7 02389  2009              MVC   OUTLINE+30(13),M301
0C1C0A D20E 22FB CA7E C39FB 02396  2010              MVC   OUTLINE+50(15),M302
0C1C1C D20C 2311 CA8D C3A11 023A5  2011              MVC   OUTLINE+72(13),M303
0C1C16 58FC 204C             0374C  2012              L     15,ALINEOUT
0C1C1A C5EF                         2013              BALR  14,15
0C1C1C D209 22CF CA4C 039CF 02364  2014              MVC   OUTLINE+6(10),M297
0C1C22 D206 22DA CA9A C39DA 023B2  2015              MVC   OUTLINE+17(7),M304
001C28 D20B 22E7 CA5B 039E7 02373  2016              MVC   OUTLINE+30(12),M299
0C1C2E D20B 22FC CA5B C39FC 02373  2017              MVC   OUTLINE+51(12),M299
0C1C34 D20B 2311 CA5B C3A11 02373  2018              MVC   OUTLINE+72(12),M299
0C1C3A 587C 2154             03854  2019              L     7,CCPSG                    CUMULATIVE COST  PSG
CC1C3E 5A7C 219C             0389C  2020              A     7,YCPSG
0C1C42 507C 2154             03854  2021              ST    7,CCPSG
0C1C46 4E70 2CCC             03700  2022              CVD   7,DW
0C1C4A DE0B 22E7 2CC3 C39E7 037C3  2023              ED    OUTLINE+30(12),DW+3
0C1C5C 587C 2158             03858  2024              L     7,CCUPSG                   CUMULATIVE COST  UPSG
0C1C54 5A7C 21AC             038A0  2025              A     7,YCUPSG
0C1C58 5070 2158             03858  2026              ST    7,CCUPSG
0C1C5C 4E7C 2CCC             037C0  2027              CVD   7,DW
0C1C6C DECB 22FC 2CC3 C39FC 03703  2028              ED    OUTLINE+51(12),DW+3
0C1C66 5870 215C             0385C  2029              L     7,CCCS                     CUMULATIVE COST  CS
0C1C6A 5A7C 21A4             038A4  2030              A     7,YCCS
0C1C6E 5070 215C             0385C  2031              ST    7,CCCS
0C1C72 4E7C 2CCC             037C0  2032              CVD   7,DW
CC1C76 DECB 2311 2CC3 C3A11 037C3  2033              ED    OUTLINE+72(12),DW+3
0C1C7C 58F0 204C             0374C  2034              L     15,ALINEOUT
0C1C8C C5EF                         2035              BALR  14,15
0C1C82 D209 22CF CA4C C39CF 02364  2036              MVC   OUTLINE+6(10),M297
0C1C88 D2C8 22DA CAA1 C39DA 023B9  2037              MVC   OUTLINE+17(9),M305
0C1C8E D20B 22E7 CA5B C39E7 02373  2038              MVC   OUTLINE+30(12),M299
0C1C94 D2CB 22FC CA5B C39FC 02373  2039              MVC   OUTLINE+51(12),M299
0C1C9A D20B 2311 CA5B C3A11 02373  2040              MVC   OUTLINE+72(12),M299
CC1CAC 587C 2160             03860  2041              L     7,CTMPSG                   CUMULATIVE TON-MILES  PSG
0C1CA4 5A7C 21A8             038A8  2042              A     7,YTMPSG
CC1CA8 507C 216C             03860  2043              ST    7,CTMPSG
0C1CAC 4E7C 2CCC             037C0  2044              CVD   7,DW
0C1CBC DE0B 22E7 2CC3 C39E7 03703  2045              ED    OUTLINE+30(12),DW+3
CC1CB6 587C 2164             03864  2046              L     7,CTMUPSG                  CUMULATIVE TON-MILES  UPSG
0C1CBA 5A70 21AC             038AC  2047              A     7,YTMUPSG
0C1CBE 507C 2164             03864  2048              ST    7,CTMUPSG
0C1CC2 4E7C 2CCC             037C0  2049              CVD   7,DW
0C1CC6 DE0B 22FC 2CC3 C39FC 037C3  2050              ED    OUTLINE+51(12),DW+3
0C1CCC 5870 2168             03868  2051              L     7,CTMCS                    CUMULATIVE TON-MILES  CS
0C1CDC 5A7C 21BC             03880  2052              A     7,YTMCS
0C1CC4 5070 2168             03868  2053              ST    7,CTMCS
0C1CD8 4E7C 2CCC             037C0  2054              CVD   7,DW
0C1CDC DECB 2311 2CC3 C3A11 03703  2055              ED    OUTLINE+72(12),DW+3
0C1CE2 58FC 204C             0374C  2056              L     15,ALINEOUT
CC1CE6 C5EF                         2057              BALR  14,15
0C1CE8 9219 22C8       C39C8        2058              MVI   CARCONT,X'19'
0C1CEC D2C9 22CF CA4C C39CF 02364  2059              MVC   OUTLINE+6(10),M297
0C1CF2 D2C3 22DA CAAA C39DA 023C2  2060              MVC   OUTLINE+17(4),M306
0C1CF8 D2CB 22E7 CA5B C39F7 02373  2061              MVC   OUTLINE+30(12),M299
0C1CFE D2CB 22FC CA5B C39FC 02373  2062              MVC   OUTLINE+51(12),M299
0C1DC4 D2CB 2311 CA5B C3A11 02373  2063              MVC   OUTLINE+72(12),M299
0C1DCA 587C 216C             0386C  2064              L     7,CTPSG                    CUMULATIVE TONS  PSG
0C1DCE 5A7C 21B4             038B4  2065              A     7,YTPSG
0C1D12 5C7C 216C             0386C  2066              ST    7,CTPSG
0C1D16 4E7C 2CCC             037C0  2067              CVD   7,DW
0C1D1A DE0B 22E7 2CC3 C39F7 03703  2068              ED    OUTLINE+30(12),DW+3
0C1D2C 587C 217C             03870  2069              L     7,CTUPSG                   CUMULATIVE TONS  UPSG
0C1D24 5A7C 21B8             038B8  2070              A     7,YTUPSG
0C1D28 5C7C 217C             03870  2071              ST    7,CTUPSG
0C1D2C 4E7C 2CCC             03700  2072              CVD   7,DW
0C1D3C DECB 22FC 2CC3 C39FC 03703  2073              ED    OUTLINE+51(12),DW+3
0C1D36 587C 2174             03874  2074              L     7,CTCS                     CUMULATIVE TONS  CS
0C1D3A 5A7C 21BC             038BC  2075              A     7,YTCS
0C1D3E 5C70 2174             03874  2076              ST    7,CTCS
0C1D42 4E70 2CCC             037C0  2077              CVD   7,DW
0C1D46 DE0B 2311 2CC3 C3A11 03703  2078              ED    OUTLINE+72(12),DW+3
0C1D4C 58FC 2C4C             0374C  2079              L     15,ALINEOUT
0C1D5C C5EF                         2080              BALR  14,15
0C1D52 9211 22C8       C39C8        2081              MVI   CARCONT,X'11'
0C1D56 D209 22CD CA4C C39DD 02364  2082              MVC   OUTLINE+20(10),M297
0C1D5C D217 22E8 CAAE C39E8 023C6  2083              MVC   OUTLINE+31(24),M307
CC1D62 D2CB 23C1 CA5B C3AC1 02373  2084              MVC   OUTLINE+56(12),M299
CC1D68 587C 219C             03890  2085              L     7,CTRCST
0C1D6C 5A70 21CC             038C0  2086              A     7,YTRCST                   CUMULATIVE TRANSPORTATION COST
0C1D7C 5070 219C             03890  2087              ST    7,CTRCST
0C1D74 4E7C 2CCC             037C0  2088              CVD   7,DW
0C1D78 DECB 2301 2CC3 C3AC1 037C3  2089              ED    OUTLINE+56(12),DW+3
0C1D7E 58F0 204C             0374C  2090              L     15,ALINEOUT
0C1D82 05EF                         2091              BALR  14,15
0C1D84 D209 22DD CA4C C39DD 02364  2092              MVC   OUTLINE+20(10),M297
001D8A D21E 22E8 CAC6 C39E8 023DE  2093              MVC   OUTLINE+31(31),M308
0C1D9C D20B 2308 CA5B C3AC8 02373  2094              MVC   OUTLINE+63(12),M299
0C1D96 5870 2194             03894  2095              L     7,CTONSOUT                 CUMULATIVE TONS FROM OUTSIDE
001D9A 5A7C 21C4             038C4  2096              A     7,YTONSOUT
0C1D9E 5070 2194             03894  2097              ST    7,CTONSOUT
0C1DA2 4E7C 2CC0             037C0  2098              CVD   7,DW
0C1DA6 DECB 2308 2CC3 C3AC8 03703  2099              ED    OUTLINE+63(12),DW+3
0C1DAC 58FC 204C             0374C  2100              L     15,ALINEOUT
0C1DBC 05EF                         2101              BALR  14,15
0C1DB2 D209 22DD CA4C C39DD 02364  2102              MVC   OUTLINE+20(10),M297
```

```
  LCC  OBJECT CODE     ADDR1 ADDR2  STMT   SOURCE STATEMENT                                                F01AUG68  5/30/69

0C1CB8 D227 22E8 CAE5 039E8 023FD  2103             MVC   OUTLINE+31(40),M309
0C1DBE D20B 2311 CA5B C3A11 02373  2104             MVC   OUTLINE+72(12),M299                           CUMULATIVE COST FROM OUTSIDE
0C1CC4 5870 2198            03898  2105             L     7,CCOUTS
0C1CC8 5A7C 21C8            038C8  2106             A     7,YCOUTS
0C1DCC 5070 2198            03898  2107             ST    7,CCOUTS
0C1DEC 4E7C 2CCC            037C0  2108             CVD   7,DW
0C1CC4 DE0B 2311 2CC3 03A11 037C3  2109             ED    OUTLINE+72(12),DW+3
0C1CCA 58FC 2C4C            0374C  2110             L     15,ALINEOUT
0C1CDE C5EF                        2111             BALR  14,15
0C1CEC D209 22DD CA4C C39DD 02364  2112             MVC   OUTLINE+20(10),M297
0C1CE6 D2C8 22E8 CBCD 039E8 02425  2113             MVC   OUTLINE+31(9),M310
0C1CEC D20B 22F2 CA5B 039F2 02373  2114             MVC   OUTLINE+41(12),M299
0C1CF2 587C 2184            03884  2115             L     7,TOTCOST                                     TOTAL COST
CC1CF6 5A70 CA40            02358  2116             A     7,TDOL
CC1CFA 5C7C 2184            03884  2117             ST    7,TOTCOST
CC1CFE 4E7C 2CCC            037C0  2118             CVD   7,DW
CC1EC2 DE0B 22F2 2CC3 C39F2 037C3  2119             ED    OUTLINE+41(12),DW+3
0C1EC8 58FC 204C            0374C  2120             L     15,ALINEOUT
0C1ECC C5EF                        2121             BALR  14,15
CC1ECE D209 22DD CA4C C39DD 02364  2122             MVC   OUTLINE+20(10),M297
0C1E14 D224 22E8 CB16 C39E8 0242E  2123             MVC   OUTLINE+31(37),M311
CC1E1A D2CB 230D CA5B C3ACD 02373  2124             MVC   OUTLINE+68(12),M299
CC1E2C 587C 2188            03888  2125             L     7,TOTTM                                       TOTAL TONS MATL WASTED
CC1E24 5A7C CA44            0235C  2126             A     7,TTM                                               AT Q'S
0C1E28 5C7C 2188            03888  2127             ST    7,TOTTM
0C1E2C 4E7C 2CCC            037C0  2128             CVD   7,DW
0C1E3C DEC8 230D 2CC3 C3ACD 037C3  2129             ED    OUTLINE+68(12),DW+3
CC1E36 58FC 2C4C            0374C  2130             L     15,ALINEOUT
0C1E3A C5EF                        2131             BALR  14,15
0C1E3C D209 22DD CA4C C39DD 02364  2132             MVC   OUTLINE+20(10),M297
0C1E42 0205 22E8 CB3B 039E8 02453  2133             MVC   OUTLINE+31(6),M312
0C1E48 D2CB 22EF CA5B C39EF 02373  2134             MVC   OUTLINE+38(12),M299
0C1E4E 587C 218C            0388C  2135             L     7,TOTTONS
CC1E52 5A7C CA3C            02354  2136             A     7,TT
CC1E56 5C7C 218C            0388C  2137             ST    7,TOTTONS
0C1E5A 4E7C 2CCC            037C0  2138             CVD   7,DW
0C1E5E DE0B 22EF 2CC3 039FF 037C3  2139             ED    OUTLINE+38(12),DW+3
0C1E64 58FC 2C4C            0374C  2140             L     15,ALINEOUT
CC1E68 C5EF                        2141             BALR  14,15
0C1E6A D209 22DD CA4C C39DD 02364  2142             MVC   OUTLINE+20(10),M297
CC1E7C D226 22E8 CB41 C39E8 02459  2143             MVC   OUTLINE+31(39),M313
0C1E76 D2CB 231C CA5B C3A10 02373  2144             MVC   OUTLINE+71(12),M299
0C1E7C 5870 2178            03878  2145             L     7,CMWTD                                       CUMULATIVE MATL WASTED
0C1E8C 5A7C 214C            0384C  2146             A     7,MWTD                                               TO DATE
0C1E84 5C7C 2178            03878  2147             ST    7,CMWTD
0C1E8B 4E7C 2CCC            037C0  2148             CVD   7,DW
0C1E8C CE0B 231C 2CC3 C3A10 037C3  2149             ED    OUTLINE+71(12),DW+3
CC1E92 58FC 2C4C            0374C  2150             L     15,ALINEOUT
0C1E96 C5EF                        2151             BALR  14,15
0C1E98 D209 22DD CA4C C39DD 02364  2152             MVC   OUTLINE+20(10),M297
CC1E9E C22C 22E8 CB68 039E8 02480  2153             MVC   OUTLINE+31(45),M314
0C1EA4 D2CB 2315 CA5B C3A15 02373  2154             MVC   OUTLINE+76(12),M299
0C1EAA 587C 217C            0387C  2155             L     7,CMWTDPQ                                     CUMULATIVE MAT'L WASTED
0C1EAE 5A7C 215C            0385C  2156             A     7,MWTDPQ                                             AT PQ'S
0C1EB2 5C70 217C            0387C  2157             ST    7,CMWTDPQ
0C1EB6 4E7C 2CCC            037C0  2158             CVD   7,DW
CC1EBA CECB 2315 2CC3 C3A15 037C3  2159             ED    OUTLINE+76(12),DW+3
CC1ECC 58FC 2C4C            0374C  2160             L     15,ALINEOUT
0C1EC4 05EF                        2161             BALR  14,15
0C1EC6 9289 22C8       C39C8       2162             MVI   CARCONT,X'89'
CC1ECA D209 22DD CA4C C39DD 02364  2163             MVC   OUTLINE+20(10),M297
0C1ECC D210 22E8 CB95 039E8 024AD  2164             MVC   OUTLINE+31(17),M315
0C1EC6 D2CB 22FA CA5B C39FA 02373  2165             MVC   OUTLINE+49(12),M299
CC1ECC 587C 218C            03880  2166             L     7,TOTMATLW
CC1EEC 5A7C 214C            0384C  2167             A     7,MWTD                                        TOTAL MAT'L WASTED
0C1EE4 5A7C 2150            03850  2168             A     7,MWTDPQ
0C1EE8 5070 218C            03880  2169             ST    7,TOTMATLW
0C1EEC 4E70 2CCC            037C0  2170             CVD   7,DW
0C1EFC DE0B 22FA 2CC3 C39FA 03703  2171             ED    OUTLINE+49(12),DW+3
0C1EF6 58FC 2C4C            0374C  2172             L     15,ALINEOUT
CC1EFA C5EF                        2173             BALR  14,15
                                   2174 ** THE NEXT SECTION WRITES USAGE AT QUARRIES DURING YEAR
0C1EFC 9219 22C8       C39C8       2175             MVI   CARCONT,X'19'
0C1FCC D21F 22E0 CBCB C39E0 024E3  2176             MVC   OUTLINE+23(32),M317
0C1FC6 D2C7 2304 254B C3AC4 03C4B  2177             MVC   OUTLINE+59(8),BYM+6
CC1FCC 1877                        2178             SR    7,7
0C1FCE 4370 2272            03972  2179             IC    7,YEAR
0C1F12 4E7C 2CCC            037C0  2180             CVD   7,DW
0C1F16 DE03 23C8 2CC6 C3A08 037C6  2181             ED    OUTLINE+63(4),DW+6
0C1F1C 58FC 2C4C            0374C  2182             L     15,ALINEOUT
C01F2C 05EF                        2183             BALR  14,15
0C1F22 9211 22C8       C39C8       2184             MVI   CARCONT,X'11'
001F26 D2C8 22EF CC16 C39FF 0252E  2185             MVC   OUTLINE+38(12),M321
0C1F2C 58F0 204C            0374C  2186             L     15,ALINEOUT
0C1F3C 05EF                        2187             BALR  14,15
0C1F32 D203 22E7 CBEB C39E7 025C3  2188             MVC   OUTLINE+30(4),M318
0C1F38 D20C 22F4 CBEF C39F4 02507  2189             MVC   OUTLINE+43(13),M319
0C1F3E 58FC 2C4C            0374C  2190             L     15,ALINEOUT
0C1F42 C5EF                        2191             BALR  14,15
0C1F44 D2C3 CA48 2C6C C2360 03760  2192             MVC   ENL(4),MINONE       SET ENL = -1
0C1F4A 587C 2148            03848  2193             L     7,FQADY             LOAD REG7 WITH ADDR 1ST Q ADDED
0C1F4E 1277                        2194             LTR   7,7                 WERE ANY Q'S ADDED DURING PREV YR
0C1F5C 4780 C68C            01FA4  2195             BZ    NNOWA               IF NOT, GO TO NNQWA
                                   2196 *  AT THIS POINT, AT LEAST 1 NEW Q WAS ADDED
0C1F54 D2C3 CA48 2148 C2360 03848  2197             MVC   ENL(4),FQADY        SET ADDR OF FIRST Q ADDED
0C1F5A D209 22E4 2417 039E4 03817  2198 NQL         MVC   OUTLINE+27(10),M35+15
0C1F6C D2CB 22F4 CA5B C39F4 02373  2199             MVC   OUTLINE+43(12),M299
0C1F66 48B7 CCCC            0C000  2200             LH    11,0(7)
0C1F6A 4EBC 2CCC            037C0  2201             CVD   11,DW
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                            F01AUG68   5/30/69

0C1F6E DE03 22E4 2CC6 039E4 03706  2202            ED     OUTLINE+27(4),DW+6
0C1F74 48B7 CC02            0C002  2203            LH     11,2(7)
0C1F78 4EBC 2CCC            03700  2204            CVD    11,DW
0C1F7C DE03 22EA 2CC6 C39EA 03706  2205            ED     OUTLINE+33(4),DW+6
0C1F82 58BC 704C            0004C  2206            L      11,76(0,7)
0C1F86 4EBC 2CCC            03700  2207            CVD    11,DW
0C1F8A DE0B 22F4 2CC3 C39F4 03703  2208            ED     OUTLINE+43(12),DW+3
CC1F9C 58FC 204C            0374C  2209            L      15,ALINEOUT
CC1F94 05EF                        2210            BALR   14,15
CC1F96 587C 7034            00034  2211            L      7,52(0,7)           LOAD REG7 WITH ADDR NEXT Q IN CHAIN
CC1F9A 1277                        2212            LTR    7,7                 ARE WE DONE
001F9C 474C C69C            01FB4  2213            BM     DONWNQ              IF YES GO TO DONWNQ
0C1FAC 47FC C642            01F5A  2214            B      NQL                 OTHERWISE, GO TO NQL
0C1FA4 D219 22E8 CBFC C39E8 02514  2215 NNQWA      MVC    OUTLINE+31(26),M320 PRINT NONE WERE ADDED
0C1FAA 9219 22C8      C39C8        2216            MVI    CARCONT,X'19'
0C1FAE 58FC 204C            0374C  2217            L      15,ALINEOUT
0C1FB2 C5EF                        2218            BALR   14,15
CC1FB4 910F 226C      C396C        2219 DONWNQ     TM     PQINFO,X'0F'        DO WE WANT TO PRINT Q INFO
0C1FB8 478C C754            0206C  2220            BZ     DONTPR              IF NOT, GO TO DONTPR
0C1FBC 9211 22C8      C39C8        2221            MVI    CARCONT,X'11'
0C1FCC D217 22ED CC22 C39ED 0253A  2222            MVC    OUTLINE+36(24),M322
CC1FC6 58FC 204C            0374C  2223            L      15,ALINEOUT
0C1FCA C5EF                        2224            BALR   14,15
CC1FCC 5870 2064            03764  2225            L      7,SQCH              LOAD REG7 WITH START Q CHAIN
0C1FCC 597C CA48            02360  2226 OLDQL      C      7,ENL               ARE WE DONE
CC1FC4 478C C7C4            0201C  2227            BE     DPROQ               IF YES, GO TO DPROQ
CC1FC8 D2C9 22E4 2417 C39E4 03817  2228            MVC    OUTLINE+27(10),M35+15
CC1FDE D20B 22F4 CA5B 039F4 02373  2229            MVC    OUTLINE+43(12),M299
0C1FE4 48B7 CCCC            0C000  2230            LH     11,0(7)
0C1FE8 4EBC 2CCC            03700  2231            CVD    11,DW
0C1FEC DE03 22E4 2CC6 C39E4 037C6  2232            ED     OUTLINE+27(4),DW+6
0C1FF2 48B7 CCC2            0C002  2233            LH     11,2(7)
0C1FF6 4EBC 2CCC            03700  2234            CVD    11,DW
0C1FFA DEC3 22EA 2CC6 C39EA 03706  2235            ED     OUTLINE+33(4),DW+6
0C2CCC 58BC 704C            0C04C  2236            L      11,76(0,7)
0C2CC4 4EBC 2CCC            037C0  2237            CVD    11,DW
0C2CC8 DECB 22F4 20C3 039F4 037C3  2238            ED     OUTLINE+43(12),DW+3
0C2CCE 58FC 204C            0374C  2239            L      15,ALINEOUT
0C2C12 C5EF                        2240            BALR   14,15
0C2C14 5870 7034            00034  2241            L      7,52(0,7)           LOAD REG7 WITH NEXT Q IN CHAIN
0C2C18 47FC C6B8            01FD0  2242            B      OLDQL               GO TO OLDQL
002C1C D21B 22E7 CC3A C39E7 02552  2243 DPROQ      MVC    OUTLINE+30(28),M323
0C2C22 58FC 2C4C            0374C  2244            L      15,ALINEOUT
0C2C26 C5EF                        2245            BALR   14,15
0C2C28 587C 2CCC            0370C  2246            L      7,AOSQ              LOAD REG7 WITH ADDR OUTSIDE Q'S
0C2C2C D5C1 7CCC 2060 CCCC0 03760  2247 AWDWOQ     CLC    0(2,7),MINONE       ARE WE DONE WITH OUTSID Q'S
0C2C32 478C C754            0206C  2248            BE     DONTPR              IF YES, GO TO DONTPR
0C2C36 D203 22E7 CC9F 039E7 025B7  2249            MVC    OUTLINE+30(4),M325
0C2C3C 4880 7CCC            0CCC0  2250            LH     11,0(0,7)           LOAD OUTSIDE Q NUMBER
0C2C4C 4EBC 2CCC            037C0  2251            CVD    11,DW               CONVERT TO DECIMAL
0C2C44 DEC3 22E7 2CC6 C39E7 037C6  2252            ED     OUTLINE+30(4),DW+6
0C2C4A D20B 22F4 CA5B C39F4 02373  2253            MVC    OUTLINE+43(12),M299
0C2C5C 58BC 7C0C            0000C  2254            L      11,12(0,7)          LOAD PRESENT USAGE OUTSIDE QUARRY
0C2C54 4EBC 2CCC            037C0  2255            CVD    11,DW               CONVERT TO DECIMAL
0C2C58 DE0B 22F4 2CC3 039F4 037C3  2256            ED     OUTLINE+43(12),DW+3
0C2C5E 58FC 204C            0374C  2257            L      15,ALINEOUT
0C2062 05EF                        2258            BALR   14,15
0C2C64 417C 7C1C            00010  2259            LA     7,16(0,7)           LOAD REG7 WITH ADDR NEXT OUTSIDE Q
0C2C68 47FC C714            0202C  2260            B      AWDWOQ              GO TO AWDWOQ
0C2C6C                             2261 DONTPR     EQU    *
0C2C6C 1B44                        2262            SR     4,4                 CLEAR REG 4
0C2C6E 434C 2272            03972  2263            IC     4,YEAR              LOAD YEAR IN REG 4
0C2C72 414C 4CC1            0CC01  2264            LA     4,1(0,4)            ADD 1 TO YEAR
0C2C76 424C 2272            03972  2265            STC 4,YEAR                 STORE UPDATED YEAR
0C2C7A D5C0 2272 2266 C3972 03966  2266            CLC    YEAR(1),MAXYEAR     ARE WE DONE WITH SIMULATION
0C2C8C 472C CACA            02322  2267            BH     DONESIM             IF SO GO TO DONESIM
0C2C84 585C 2C64            03764  2268            L      5,SQCH              LOAD 5 WITH START Q CHAIN
002C88 1255                        2269 PPDLTEST   LTR    5,5                 IS ADDR NEG, (ARE WE DONE)
0C2C8A 47BC C77A            02092  2270            BNM    IQAPP               IF NOT, GO TO IS Q A PP
0C2C8E 47FC C7A0            02088  2271            B      ATACTBR             GO TO ATACTBR
0C2092 9101 5C05      CCCC5        2272 IQAPP      TM     5(5),X'01'          IS IT A PROCESSING PLANT
0C2C96 478C C798            02080  2273            BZ     PPDLOOP             IF NOT, GO TO PP DEPRECIATION LOOP
                                   2274 *  AT THIS POINT IT IS A PROCESSING PLANT
0C209A 1B66                        2275            SR     6,6                 CLEAR REG 6
0C2C9C 4360 502A            0C02A  2276            IC     6,42(0,5)           STORE LIFE PP IN REG 6
0C2CAC C66C                        2277            BCTR   6,0                 SUBTRACT ONE FROM PP LIFE
0C2CA2 1266                        2278            LTR    6,6                 IS LIFE GREATER THAN 0
0C2CA4 4720 C794            020AC  2279            BP     SULPP               IF YES, GO TO STORE UPDATED LIFE PP
                                   2280 *  AT THIS POINT, LIFE IS 0 AND A NEW PP MUST BE PURCHASED
0C2CA8 436C 24C7            03807  2281            IC     6,LNPP              LOAD REG6 WITH LIFE NEW PR PLT
0C2CAC 4260 502A            0002A  2282 SULPP      STC    6,42(0,5)           STORE UPDATED LIFE
0C2CBC 5850 5C34            0C034  2283 PPDLOOP    L      5,52(0,5)           LOAD 5 WITH ADDR NEXT Q
0C2CB4 47FC C77C            02088  2284            B      PPDLTEST            GO TO PPDLTEST
0C2CB8 D5CC 2272 2273 C3972 03973  2285 ATACTBR    CLC    YEAR,YRNCTBR        ARE THERE ANY CARDS TO BE READ
0C2CBE 478C C7D2            020EA  2286            BE     SETSW               IF SO, GO TO SETSW
0C2CC2 91FF 2274      C3974        2287            TM     SWITCH,X'FF'        IS SWITCH 11111111
0C2CC6 478C C9F8            02310  2288            BZ     BEGINITT            IF NOT, GO TO BEGINITT
0C2CCA 58FC 2048            03748  2289            L      15,ACARDIN          READ YEAR NEXT CARDS ARE TO BE READ
0C2CCE 05EF                        2290            BALR   14,15               ''
0C2CDC F271 2CCC 2277 C37C0 03977  2291            PACK   DW(8),INPUT(2)      PACK YEAR
0C2CD6 96CF 2CC7      C3707        2292            OI     DW+7,X'0F'          MAKE BLANK A 0
0C2CDA 4FB0 2CCC            03700  2293            CVB    11,DW               CONVERT TO BINARY IN REG11
CC2CDE 42BC 2273            03973  2294            STC    11,YRNCTBR          STORE IN YR NEXT CARD TO BE READ
002CE2 94C0 2274      C3974        2295            NI     SWITCH,X'00'        SET SWITCH = 00000000
0C2CE6 47FC C7AC            020B8  2296            B      ATACTBR             GO TO ATACTBR
                                   2297 *  AT THIS POINT, AT LEAST 1 INTERMEDIATE CARD IS TO BE READ
0C2CEA 96FF 2274      C3974        2298 SETSW      OI     SWITCH,X'FF'        SET SWITCH = 11111111
0C2CEE 588C 2010            03710  2299            L      8,AMATRIX           LOAD REG8 WITH ADDR MATRIX
0C2CF2 58FC 2048            03748  2300 RINTCD     L      15,ACARDIN          READ INTERMEDIATE CARD
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                  F01AUG68  5/30/69

0C20F6 05EF                        2301          BALR  14,15               ''
002CF8 D501 2277 2275 03977 03975  2302          CLC   INPUT(2),STARSTAR   COMPARE WITH ** FOR END OF DATA SET
0C20FE 4780 C9F8            02310  2303          BE    BEGINITT            IF END DATA SET, GO TO BEGINITT
                                   2304 *  AT THIS POINT WE HAVE NOT REACHED THE END OF THE DATA SET NOR IS
0C2102 F272 2CC0 2277 C3700 03977  2305          PACK  DW(8),INPUT(3)      PACK ROW
0C21C8 960F 2CC7      03707        2306          OI    DW+7,X'0F'          MAKE BLANK A 0
0C21CC 4FB0 2C00            03700  2307          CVB   11,DW               CONVERT TO BINARY IN REG11
0C211C 40B0 226E            0396E  2308          STH   11,IDROW            STORE IN IDROW
0C2114 F272 2CC0 227A C3700 0397A  2309          PACK  DW(8),INPUT+3(3)    PACK COL
0C211A 960F 2C07      C3707        2310          OI    DW+7,X'0F'          MAKE BLANK A 0
0C211E 4FB0 2CCC            03700  2311          CVB   11,DW               CONVERT TO BINARY IN REG11
0C2122 40B0 227C            03970  2312          STH   11,IDCOL            STORE IN IDCOL
0C2126 954C 227D      0397D        2313          CLI   INPUT+6,C' '        IS ZONING LAW BLANK
0C212A 4780 C834            0214C  2314          BE    DCZL                IF SO, GO TO DCZL
0C212E D2CC 23F8 227D 03AF8 0397D  2315          MVC   ZLAW(1),INPUT+6     SET ZONING LAW CONFIGURATION
                                   2316          CALL  SETZL               SET ZONING LAW CONFIGURATION
0C2134                             2317+         CNOP  0,4
0C2134 47FC C824            0213C  2318+         B     *+8 BRANCH AROUND VCON
0C2138 CCCCCCCC                    2319+IHB0015B DC    V(SETZL) ENTRY POINT ADDRESS
00213C 58FC C820            02138  2320+         L     15,IHB0015B LOAD 15 WITH ENTRY ADR
0C214C 05EF                        2321+         BALR  14,15 BRANCH TO ENTRY POINT
0C2142 D2C0 23FE 23F9 C3AFE 03AF9  2322          MVC   IDZL(1),ZLAWD       AND MOVE TO IDZL
0C2148 47FC C838            02150  2323          B     ZLDET               GO TO ZLDET
0C214C 924C 23FE      C3AFE        2324 DCZL     MVI   IDZL,C' '           SET IDZL = BLANK
0C215C 96F0 229B      0399B        2325 ZLDET    OI    INPUT+36,X'F0'      CONVERT DEVFO BLANK TO 0 IF NECESARY
0C2154 95FC 229B      0399B        2326          CLI   INPUT+36,X'F0'      IS A DEVELOPMENT FORECASTED
0C2158 478C C7DA            020F2  2327          BE    RINTCD              IF NOT, GO TO RINTCD
                                   2328 *  AT THIS POINT A DEVELOPMENT IS FORECASTED
0C215C F27C 2CCC 227E C3700 0397F  2329          PACK  DW(8),INPUT+7(1)       PACK IOCC
0C2162 96CF 2CC7      C3707        2330          OI    DW+7,X'0F'
0C2166 4FBC 2CCC            037C0  2331          CVB   11,DW
0C216A 42BC CCA3            025BB  2332          STC   11,IDIOCC           STORE IOCC IN IDIOCC
0C216E F273 2CC0 229F C3700 0399F  2333          PACK  DW(8),INPUT+40(4)   PACK PROCESSED S&G TO COMPLETION
0C2174 96CF 2CC7      C37C7        2334          OI    DW+7,X'0F'          MAKE BLANK A 0
0C2178 4FBC 2CCC            037C0  2335          CVB   11,DW               CONVERT TO BINARY IN REG11
0C217C 1BAA                        2336          SR    10,10               CLEAR REG 10
0C217E 5CAC 2144            03844  2337          M     10,THOUSAND         MULTIPLY BY 1000
0C2182 50BC 2CD8            037D8  2338          ST    11,IDPSGTC          STORE IN IDPSGTC
CC2186 D2CC 23F4 22A3 03AF4 039A3  2339          MVC   QCA(1),INPUT+44     MOVE QUALITY TO QCA
                                   2340          CALL  SETQUAL             SET QUALITY
CC218C                             2341+         CNOP  0,4
CC218C 47FC C87C            02194  2342+         B     *+8 BRANCH AROUND VCON
0C219C CCCCCCCC                    2343+IHB0016B DC    V(SETQUAL) ENTRY POINT ADDRESS
0C2194 58FC C878            02190  2344+         L     15,IHB0016B LOAD 15 WITH ENTRY ADR
CC2198 C5EF                        2345+         BALR  14,15 BRANCH TO ENTRY POINT
CC219A D2CC 24CC 23F5 C3BC0 03AF5  2346          MVC   IDMQPSG(1),QCAD     MOVE TO IDMQPSG
0C21AC F272 2CCC 22A4 037C0 039A4  2347          PACK  DW(8),INPUT+45(3)   PACK PERCENT S&G TO COMPLETION
CC21A6 960F 2C07      C37C7        2348          OI    DW+7,X'0F'          MAKE BLANK A 0
0C21AA 4FB0 2CC0            037C0  2349          CVB   11,DW               CONVERT TO BINARY IN REG11
0C21AE 42BC 23FF            03AFF  2350          STC   11,IDPERSG          STORE IN IDPERSG
CC21B2 F273 2CC0 22A7 C37C0 039A7  2351          PACK  DW(8),INPUT+48(4)   PACK UNPROCESSED S&G TO COMPLETION
CC21B8 960F 2CC7      C3707        2352          OI    DW+7,X'0F'          MAKE BLANK A 0
CC21BC 4FBC 2CCC            037C0  2353          CVB   11,DW               CONVERT TO BINARY IN REG11
0C21CC 1BAA                        2354          SR    10,10               CLEAR REG10
CC21C2 5CAC 2144            03844  2355          M     10,THOUSAND         MULTIPLY BY 1000
CC21C6 95C1 CCA3      C25BB        2356          CLI   IDIOCC,X'01'        DOES DEVFO GO THRU OCCUPIED AREA
CC21CA 478C C8C0            021D8  2357          BE    DDRED               IF SO GO TO DDRED
0C21CE 1BAA                        2358          SR    10,10               OTHERWISE CLEAR REG10
0C21DC 5CAC 21DC            038D0  2359          M     10,PERCFQ           MULTIPLY BY PERCENT UPSG REQ'D
0C21D4 5DAC 214C            0384C  2360          D     10,HUNDRED          AND DIVIDE BY 100
CC21D8                             2361 DDRED    EQU   *
0C21D8 50BC 20DC            037DC  2362          ST    11,IDUSGTC          STORE IN IDUSGTC
CC21DC D2C0 23F4 22AB 03AF4 039AB  2363          MVC   QCA(1),INPUT+52     MOVE QUALITY TO QCA
                                   2364          CALL  SETQUAL             SET QUALITY
0C21E2 C7CC                        2365+         CNOP  0,4
0C21E4 47F0 C8D4            021EC  2366+         B     *+8 BRANCH AROUND VCON
0C21E8 CCCCCCCC                    2367*IHB0017B DC    V(SETQUAL) ENTRY POINT ADDRESS
0C21EC 58F0 C8DC            021E8  2368+         L     15,IHB0017B LOAD 15 WITH ENTRY ADR
0C21FC 05EF                        2369+         BALR  14,15 BRANCH TO ENTRY POINT
0021F2 D2CC 2401 23F5 C3B01 03AF5  2370          MVC   IDMQUSG(1),QCAD     MOVE TO IDMQUSG
0C21F8 F273 2CCC 22AC C37C0 039AC  2371          PACK  DW(8),INPUT+53(4)   PACK CS TO COMPLETION
0C21FE 960F 2CC7      C3707        2372          OI    DW+7,X'0F'          MAKE BLANK A 0
0C2202 4FBC 2CCC            03700  2373          CVB   11,DW               CONVERT TO BINARY IN REG11
0C2206 1BAA                        2374          SR    10,10               CLEAR REG10
0C2208 5CAC 2144            03844  2375          M     10,THOUSAND         MULTIPLY BY 1000
0C22CC 50BC 20EC            037E0  2376          ST    11,IDCSTC           STORE IN IDCSTC
0C221C D2CC 23F4 22BC C3AF4 039B0  2377          MVC   QCA(1),INPUT+57     MOVE QUALITY TO QCA
                                   2378          CALL  SETQUAL             SET QUALITY
0C2216 07CC                        2379*         CNOP  0,4
0C2218 47FC C908            02220  2380+         B     *+8 BRANCH AROUND VCON
00221C CCCCCCCC                    2381*IHB0018B DC    V(SETQUAL) ENTRY POINT ADDRESS
0C222C 58FC C904            0221C  2382+         L     15,IHB0018B LOAD 15 WITH ENTRY ADR
0C2224 05EF                        2383+         BALR  14,15 BRANCH TO ENTRY POINT
0C2226 D2CC 2402 23F5 C3B02 03AF5  2384          MVC   IDMQCS(1),QCAD      MOVE TO IDMQCS
00222C F271 2CCC 22B1 C37C0 039B1  2385          PACK  DW(8),INPUT+58(2)   PACK YEARS TO COMPLETION
0C2232 960F 2CC7      03707        2386          OI    DW+7,X'0F'          MAKE BLANK A 0
0C2236 4FB0 2CCC            037C0  2387          CVB   11,DW               CONVERT TO BINARY IN REG11
0C223A 42BC 2403            03803  2388          STC   11,IDYTC            STORE IN IDYTC
0C223E D501 8CC0 226E C0000 0396E  2389 RACCHEK  CLC   0(2,8),IDROW        IS ROW MATRIX = ROW INTER CARD
0C2244 4770 C9E6            022FE  2390          BNE   CHEKNGR             IF NOT GO TO CHEKNGR
0C2248 D501 8002 227C C0002 03970  2391          CLC   2(2,8),IDCOL        IS COL MATRIX = COL INTER CARD
0C224E 4770 C9E6            022FE  2392          BNE   CHEKNGR             IF NOT GO TO CHEKNGR
                                   2393 *  AT THIS POINT, ROW & COL IN MATRIX = ROW & COL ON INTERMEDIATE CARD
0C2252 9540 23FE      03AFE        2394 UGI      CLI   IDZL,C' '           WAS ZONING LAW BLANK
0C2256 4780 C948            02260  2395          BE    DONTUPZL            IF YES, GO TO DONT UPDATE ZONING LAW
0C225A D2C0 8004 23FE C0004 03AFE  2396          MVC   4(1,8),IDZL         UPDATE ZONING LAW
0C226C 95F0 229B      C399B        2397 DONTUPZL CLI   INPUT+36,X'F0'      IS A DEVELOPMENT FORECASTED
0C2264 4780 C9E6            022FE  2398          BE    CHEKNGR             IF NOT, GO TO CHEKNGR
                                   2399 *  AT THIS POINT THERE IS A DEVELOPMENT FORECASTED WHICH WILL BEGIN
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                                   F01AUG68   5/30/69

                                   2400 *  DURING THE PRESENT YEAR
0C2268 95C0 802B       CC02B       2401             CLI   43(8),X'00'          IS IT STILL A WORK IN PROCESS
0C226C 478C C962             0227A 2402             BE    NSWIP                IF NOT, GO TO NSWIP
0C2270 508C 20AC             037A0 2403             ST    8,AWIPTBD            IF SO, DELETE IT FROM WIP CHAIN
0C2274 58F0 2C30             03730 2404             L     15,ASRDWIP           ''
0C2278 05EF                        2405             BALR  14,15                ''
0C227A                             2406 NSWIP       EQU   *
0C227A 95C0 8019       C0019       2407             CLI   25(8),X'00'          IS IT A DEVFO
0C227E 478C C974             0228C 2408             BE    NSDEVFO              IF NOT, GO TO NSDEVFO
0C2282 5080 209C             0379C 2409             ST    8,ADEVTBD            DELETE IT FROM DEVFO CHAIN
0C2286 58FC 202C             0372C 2410             L     15,ASRDDEV           ''
0C228A 05EF                        2411             BALR  14,15                ''
0C228C                             2412 NSDEVFO     EQU   *
0C228C 9201 8019       CC019       2413             MVI   25(8),X'01'          SET DEVFO INDICATOR = 1
0C229C 508C 208C             0378C 2414             ST    8,ADEVTBA            STORE ADDR OF DEVFO TO BE ADDED
0C2294 58F0 201C             0371C 2415             L     15,ASRADEV           ADD DEVFO
0C229E 05EF                        2416             BALR  14,15                ''
0C229A D2CC 801B 24C3 CC01B 03803  2417             MVC   27(1,8),IDYTC        STORE YEARS TO COMPLETION
0C22AC 588C 20D8             037D8 2418             L     11,IDPSGTC           LOAD REG11 WITH PROC S&G TO COMPLET
0C22A4 5ABC 8C1C             0001C 2419             A     11,28(0,8)           ADD PR S&G REMAINING IN MATRIX
0C22A8 50B0 801C             0001C 2420             ST    11,28(0,8)           STORE PROCESSED S&G TO COMPLETION
0C22AC 588C 20DC             037DC 2421             L     11,IDUSGTC           LOAD REG11 WITH UNPR S&G TO COMPL
0C228C 5ABC 8C2C             0C020 2422             A     11,32(0,8)           ADD REMAINING FROM MATRIX
0C2284 50BC 8C2C             00020 2423             ST    11,32(0,8)           STORE UNPROCESSED S&G TO COMPLETION
0C2288 588C 20EC             037E0 2424             L     11,IDCSTC            LOAD REG11 WITH CS TO COMPLETION
0C228C 5ABC 8024             00024 2425             A     11,36(0,8)           ADD REMAINING CS FROM MATRIX
0C22CC 50B0 8024             00024 2426             ST    11,36(0,8)           STORE CS TO COMPLETION
0C22C4 D2CC 8C1A 2272 CC01A 03972  2427             MVC   26(1,8),YEAR         SET YEAR DEVFO WILL START = YEAR
0C22CA D2CC 8028 24CC C0028 038C0  2428             MVC   40(1,8),IDMQPSG      STORE MIN QUAL PROCESSED S&G
0C22CC C2CC 8C29 23FF CC029 03AFF  2429             MVC   41(1,8),IDPERSG      STORE PERCENT S&G
0C22C6 D2CC 802C 24C1 C002C 03801  2430             MVC   44(1,8),IDMQUSG      STORE MIN QUAL UNPROCESSED S&G
0C22CC C2CC 802D CCA3 C002D 025B8  2431             MVC   45(1,8),IDIOCC       SET IOCC BYTE
CC22E2 D2CC 8C3C 24C2 C0030 03802  2432             MVC   48(1,8),IDMQCS       STORE MIN QUAL CS
0C22E8 C2C3 8C4C 2C6C CC040 03760  2433             MVC   64(4,8),MINONE       SET QUARRY POINTERS TO MINUS 1
0C22EE C2C3 8C44 2C6C CC044 03760  2434             MVC   68(4,8),MINONE       ''
0C22F4 C2C3 8C48 2C6C C0048 03760  2435             MVC   72(4,8),MINONE       ''
0C22FA 47FC C7DA             020F2 2436             B     RINTCD               GO TO RINTCD
0C22FE 418C 8054             00054 2437 CHEKNGR     LA    8,84(0,8)             LOAD ADDR NEXT GRID INTO REG8
0C23C2 588C 8CCC             0CCC0 2438             L     11,0(0,8)            LOAD 11 WITH ROW AND COL OF GRID
CC23C6 128B                        2439             LTR   11,11                IS ROW AND COL NEG
0C23C8 474C C9FE             02316 2440             BM    GNFPEM               IF NEG, GO TO GNFPEM
0C23CC 47FC C926             0223E 2441             B     RACCHEK              GO TO RACCHEK
0C231C 58FC 2C5C             03750 2442 BEGINITT    L     15,ABEGINIT          LOAD REG15 WITH ADDR BEGINIT
CC2314 C7FF                        2443             BR    15                   AND BRANCH TO BEGINIT
0C2316                             2444 GNFPEM      EQU   *                  (GRID NOT FOUND, PRINT ERROR MESSAGE)
                                   2445 **
002316 D248 22C3 CC56 039D3 0256E  2446             MVC   OUTLINE+10(L'M324),M324
CC231C 58FC 2C4C             0374C 2447             L     15,ALINEOUT
CC232C C5EF                        2448             BALR  14,15
                                   2449 *
0C2322                             2450 DONESIM     EQU *
                                   2451             CLOSE (INDCB,,OUTDCB)
0C2322 C7CC                        2452+            CNOP  0,4
0C2324 451C CA18             02330 2453+            BAL   1,*+12 BRANCH AROUND LIST
0C2328 CC                          2454+            DC    AL1(0) OPTION BYTE
0C2329 CC08C4                      2455+            DC    AL3(INDCB) DCB ADDRESS
0C232C 80                          2456+            DC    AL1(128) OPTION BYTE
0C232D CC09A4                      2457+            DC    AL3(OUTDCB) DCB ADDRESS
0C233C CA14                        2458+            SVC   20 ISSUE CLOSE SVC
                                   2459             REEXIT
0C2332 181C                        2460+            LR    1,13
0C2334 58DC DCC4             0C004 2461+            L     13,4(,13)
0C2338                             2462+            CNOP  0,4
0C2338 47FC CA28             02340 2463+            B     *+8 BRANCH AROUND SP+LV
0C233C C0                          2464+            DC    AL1(0) SUBPOOL VALUE
0C233D CCC048                      2465+            DC    AL3(72) LENGTH
CC234C 58CC CA24             0233C 2466+            L     0,*-4 LOAD SP AND LV
0C2344 CA0A                        2467+            SVC   10 ISSUE FREEMAIN SVC
0C2346 98EC DC0C             0C00C 2468+            LM    14,12,12(13) RESTORE THE REGISTERS
0C234A 92FF DCCC       C000C       2469+            MVI   12(13),X'FF' SET RETURN INDICATION
0C234E 41F0 CCCC             0CCC0 2470+            LA    15,0(0,0) LOAD RETURN CODE
0C2352 07FE                        2471+            BR    14 RETURN
0C2354                             2472 TT          DS    F
0C2358                             2473 TDOL        DS    F
0C235C                             2474 TTM         DS    F
0C236C                             2475 ENL         DS    F
0C2364 C3E4D4E4D3C1E3C9            2476 M297        DC    C'CUMULATIVE'
0C236E E3D6E3C1C3                  2477 M298        DC    C'TOTAL'
0C2373 402C20206B2C202C            2478 M299        DC    X'4020202068202020682021 20'
0C237F E3D6E3C1D3E240C6            2479 M300        DC    C'TOTALS FOR'
002389 D7D9D6C3C5E2E2C5            2480 M301        DC    C'PROCESSED S&&G'
0C2396 E4D5D7D9D6C3C5E2            2481 M302        DC    C'UNPROCESSED S&&G'
0C23A5 C3D9E4E2C8C5C44C            2482 M303        DC    C'CRUSHED STONE'
0C23B2 C4D6D3D3C1D9E2              2483 M304        DC    C'DOLLARS'
0C23B9 E3D6D560D4C9D3C5            2484 M305        DC    C'TON-MILES'
0C23C2 E3D6D5E2                    2485 M306        DC    C'TONS'
0C23C6 E3D9C1D5E2D7C6D9            2486 M307        DC    C'TRANSPORTATION DOLLARS ='
0C23DE E3D6D5E240C6D9D6            2487 M308        DC    C'TONS FROM OUTSIDE GRID SYSTEM ='
0C23FC C3D6E2E340D4C1E3            2488 M309        DC    C'COST MATERIAL FROM OUTSIDE GRID SYSTEM ='
0C2425 C4D6D3D3C1D9E240            2489 M310        DC    C'DOLLARS ='
0C242E E3D6D560D4C9D3C5            2490 M311        DC    C'TON-MILES (WITHIN GRID SYSTEM ONLY) ='
0C2453 E3D6D5E2407E                2491 M312        DC    C'TONS ='
0C2459 E3D6D5E240E6C1E2            2492 M313        DC    C'TONS WASTED AT ZONED OUT QUARRY SITES ='
0C248C E3D6D5E240E6C1E2            2493 M314        DC    C'TONS WASTED AT ZONED OUT POTENTIAL QUARRIES ='
0C24AD D4C1E3C5D9C9C1D3            2494 M315        DC    C'MATERIAL WASTED ='
0024BE C3E4D4E4D3C1E3C9            2495 M316        DC    C'CUMULATIVE TOTALS UP TO AND INCLUDING'
0C24E3 D4C1E3C5D9C9C1D3            2496 M317        DC    C'MATERIAL USED AT QUARRIES DURING'
0C25C3 C7D9C9C4                    2497 M318        DC    C'GRID'
0C25C7 E3D6D5E240D4C1E3            2498 M319        DC    C'TONS MATERIAL'
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                                F01AUG68   5/30/69

002514 D5D640D5C5E640D8            2499 M320     DC    C'NO NEW QUARRIES WERE ADDED'
00252E D5C5E640D8E4C1D9            2500 M321     DC    C'NEW QUARRIES'
00253A D8E4C1D9D9C9C5E2            2501 M322     DC    C'QUARRIES 1 YEAR OR OLDER'
002552 D8E4C1D9D9C9C5E2            2502 M323     DC    C'QUARRIES OUTSIDE GRID SYSTEM'
                                   2503 M324     DC    C'AN INCORRECT INTERMEDIATE INPUT CARD HAS BEEN LOCATED X
00256E C1D540C9D5C3D6D9                                ABNORMAL END OF JOB'
0025B7 40202120                    2504 M325     DC    X'40202120'
0025BB                             2505 IDIOCC   DS    X
0025CC                             2506          LTORG
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                             F01AUG68   5/30/69

0C25CC                             2508          USING *,3
0C25CC 90EC DC0C            0C00C  2509 SRFLCQ   STM   14,12,12(13)        (SUBROUTINE FIND LOWEST COST QUARRY)
0C25C4 183F                        2510          LR    3,15
0C25C6 58EC 34CC            029CC  2511          L     14,ASAVLCQ
0C25CA 50ED CCC8            00008  2512          ST    14,8(13)
0C25CE 50DE CCC4            0C0C4  2513          ST    13,4(14)
0C25D2 18DE                        2514          LR    13,14
0C25D4 D203 3458 213C C2A18 0383C  2515          MVC   LOWCOST(4),LARPOSN  SET LOWEST = LARGEST POSITIVE NO.
0C25DA D2C3 211C 2C6C C3810 03760  2516          MVC   ADDRIP(4),MINONE    SET ADDRIP = -1
0C25EC D203 2114 2C6C C3814 03760  2517          MVC   QASSGNED(4),MINONE  SET QASSGNED = -1
0C25E6 92CC 24C6      C38C6        2518          MVI   OUTSI,X'00'         SET OUTSIDE INDICATOR = 0
0C25EA 5850 2118            03818  2519          L     5,WIPBE             LOAD REG5 WITH WIP BEING ESTABLISHED
0C25EF D203 2CB0 5CCC C3780 0CCC0  2520          MVC   POINT1(4),0(5)      SET POINT1 = WIP(5)
0C25F4 584C 2C64            03764  2521          L     4,SQCH              LOAD REG4 WITH START Q CHAIN
0C25F8 1866                        2522          SR    6,6                 CLEAR REG6
0C25FA 436C 21CC            038CC  2523          IC    6,INDEXT            INSERT INDEXT INTO REG6 .. 0=PSG,
                                   2524 *                                  2=UPSG, 4=CS
0C25FE 95CC 21CC      C38CC        2525          CLI   INDEXT,X'00'        ARE WE INVESTIGATING PROCESSED S&G
0C26C2 478C 30E4            026A4  2526          BE    PSGLP               IF YES, GO TO PSGLP
0C26C6 9504 21CC      C38CC        2527          CLI   INDEXT,X'04'        IS IT UNPROCESSED S&G
0C26CA 478C 3C56            02616  2528          BE    IIUPSG              IF YES, GO TO IIUPSG
                                   2529 *  AT THIS POINT IT IS CRUSHED STONE
0C26CE 9222 34C1      C2A81        2530          MVI   TYPMSK,X'22'        SET TYPMSK = X'22'
0C2612 47FC 3C5A            0261A  2531          B     FQLOOP              GO TO FQLOOP
0C2616 9242 34C1      C2A81        2532 IIUPSG   MVI   TYPMSK,X'42'        SET TYPMSK = X'42'
                                   2533 *  AT THIS POINT IT IS EITHER UNPROCESSED S&G OR CRUSHED STONE
0C261A                             2534 FQLOOP   EQU   *
0C261A 1244                        2535          LTR   4,4                 ARE WE DONE WITH ALL Q'S INSIDE GRID
0C261C 474C 322C            027E0  2536          BM    CHEKOUTS            IF YES, GO TO CHEKOUTS
0C262C 4370 34C1            02A81  2537          IC    7,TYPMSK            INSET TYPE INTO REG7
0C2624 447C 3CDC            0269C  2538          EX    7,CQ1               IS Q(4) THE CORRECT TYPE
0C2628 47EC 3CD4            02694  2539          BNO   LFNEXTQ             IF NOT, GO TO LFNEXTQ
0C262C 9104 4CC5      C00C5        2540          TM    5(4),X'04'          DOES Q(4) USE AN INTER POINT
0C263C 471C 3CD4            02694  2541          BO    LFNEXTQ             IF YES GOTO LFNEXTQ
0C2634 4376 5C28            00028  2542          IC    7,40(6,5)           INSERT QUAL REQUIRED INTO REG7
0C2638 4470 3CEC            026A0  2543          EX    7,CQ2               IS QUAL AT Q(4) WORSE THAN REQ'D
0C263C 47EC 3CD4            02694  2544          BNO   LFNEXTQ             IF WORSE, GO TO LFNEXTQ
0C264C 58BC 4CC8            0C008  2545          L     11,8(0,4)           LOAD LIFE Q(4) INTO REG11
0C2644 12BB                        2546          LTR   11,11               HAS Q(4) BEEN DEPLETED
0C2646 47DC 3CD4            02694  2547          BNP   LFNEXTQ             IF YES, GO TO LFNEXTQ
0C264A 587C 4C4C            0C04C  2548          L     7,76(0,4)           LOAD REG7 WITH MATL BEING USED
0C264E 5A76 2128            03828  2549          A     7,PPUPSG(6)         ADD PRESENT PERIOD USAGE
0C2652 597C 4CCC            0C00C  2550          C     7,12(0,4)           DOES IT EXCEED MAX YR OUTPUT
0C2656 472C 3CD4            02694  2551          BH    LFNEXTQ             IF YES, GO TO LFNEXTQ
                                   2552 *  AT THIS POINT, Q(4) IS A POTENTIAL SUPPLIER
0C265A D2C3 2CB4 4CCC C37B4 0C0C0  2553          MVC   POINT2(4),0(4)      SET POINT 2 = Q(4)
0C266C 58FC 2C34            03734  2554          L     15,ASRDIST          FIND DIST Q(4) TO WIP(5)
0C2664 C5EF                        2555          BALR  14,15               ''
0C2666 D203 2CC4 2CA4 C37C4 037A4  2556          MVC   TRANSD(4),DISTX     FIND TRANSPORTATION COST
0C266C 58FC 2C38            03738  2557          L     15,ASRTRCST         ''
0C267C C5EF                        2558          BALR  14,15               ''
0C2672 588C 2CC8            037C8  2559          L     8,FIXPTCST          LOAD TRANS COST INTO REG8
0C2676 4A8C 4C14            0C014  2560          AH    8,20(0,4)           ADD COST TO MINE & PROCESS
0C267A 4A80 4C2E            0C02E  2561          AH    8,46(0,4)           ADD AMORTIZATION COST
0C267E 598C 3458            02A18  2562          C     8,LOWCOST           IS COST LOWER THAN PREVIOUS LOW
0C2682 472C 3CD4            02694  2563          BH    LFNEXTQ             IF NOT, GO TO LFNEXTQ
                                   2564 *  AT THIS POINT, COST IS LOWER THAN PREVIOUS LOW
0C2686 504C 2114            03814  2565          ST    4,QASSGNED          STORE ADDR QUARRY ASSIGNED
0C268A 508C 3458            02A18  2566          ST    8,LOWCOST           STORE NEW LOW COST
0C268E D2C3 211C 2C6C C381C 03760  2567          MVC   ADDRIP(4),MINONE    SET INTER PT ADDR = -1
0C2694 584C 4C34            0C034  2568 LFNEXTQ  L     4,52(0,4)           LOAD REG4 WITH ADDR NEXT Q
0C2698 47FC 3C5A            0261A  2569          B     FQLOOP              GO TO FQLOOP
0C269C 91CC 4CC5      CC0C5        2570 CQ1      TM    5(4),X'00'          DETERMINE TYPE
0C26AC 91CC 4C17      CC017        2571 CQ2      TM    23(4),X'00'         DETERMINE QUALITY
0C26A4                             2572 PSGLP    EQU   *                   (PROCESSED S&G LOOP)
0C26A4 1244                        2573          LTR   4,4                 ARE WE DONE WITH Q'S IN GRID
0C26A6 474C 322C            027E0  2574          BM    CHEKOUTS            IF YES, GO TO CHEKOUTS
0C26AA 914C 4CC5      CC0C5        2575          TM    5(4),X'40'          IS IT A S&G Q
0C26AE 478C 318A            0274A  2576          BZ    CNPSGQ              IF NOT, GO TO CNPSGQ
0C26B2 9102 4005      CC0C5        2577          TM    5(4),X'02'          IS Q(4) MINING MATERIAL
0C26B6 4780 318A            0274A  2578          BZ    CNPSGQ              IF NOT, GO TO CNPSGQ
0C26BA 58BC 4CC8            00008  2579          L     11,8(0,4)           LOAD LIFE Q(4) INTO REG11
0C26BE 12BB                        2580          LTR   11,11               HAS Q(4) BEEN DEPLETED
0C26CC 47DC 318A            0274A  2581          BNP   CNPSGQ              IF YES, GO TO CNPSGQ
                                   2582 *  AT THIS POINT, Q(4) IS MINING MATERIAL AND THERE IS ENOUGH
0C26C4 91C4 4CC5      CCCC5        2583          TM    5(4),X'04'          DOES Q(4) USE AN INTER POINT
0C26C8 471C 3192            02752  2584          BO    QR4UIP              IF YES, GO TO QR4UIP
                                   2585 *  AT THIS POINT Q(4) DOES NOT USE AN INTERMEDIATE POINT
0C26CC 9101 4CC5      CCCC5        2586          TM    5(4),X'01'          IS IT A PROCESSING PLANT
0C26CC 478C 318A            0274A  2587          BZ    CNPSGQ              IF NOT, GO TO CNPSGQ
                                   2588 *  AT THIS POINT, Q(4) IS A Q AND A PP
0C26C4 437C 5C28            0C028  2589          IC    7,40(0,5)           INSERT QUAL MATL REQ INTO REG7
0C26C8 9532 4018      CC018        2590          CLI   24(4),50            IS Q(4) AT LEAST 50 PERCENT SAND
0C26CC 478C 312C            026EC  2591          BNL   TSQQ                IF YES, GO TO TSQQ
0C26EC 4470 313C            026FC  2592          EX    7,CPSGQ2            IS GRAVEL QUAL WORSE THAN REQ'D
0C26E4 47EC 318A            0274A  2593          BNO   CNPSGQ              IF WORSE, GO TO CNPSGQ
0C26E8 47FC 314C            027C0  2594          B     QOK                 OTHERWISE, GO TO QOK
0C26EC 4470 3138            026F8  2595 TSQQ     EX    7,CPSGQ1            IS SAND QUALITY WORSE THAN REQ'D
0C26FC 47EC 318A            0274A  2596          BNO   CNPSGQ              IF WORSE, GO TO CNPSGQ
0C26F4 47F0 3140            02700  2597          B     QOK                 OTHERWISE, GO TO QOK
0C26F8 91CC 4016      C0016        2598 CPSGQ1   TM    22(4),X'00'         TEST SAND QUALITY
0C26FC 910C 4017      C0017        2599 CPSGQ2   TM    23(4),X'00'         TEST GRAVEL QUALITY
0C27CC                             2600 QOK      EQU   *                   (Q(4) IS OK TO BE USED)
0C27CC 5870 404C            0004C  2601          L     7,76(0,4)           LOAD REG7 WITH MATL BEING USED
0C27C4 5A70 2128            03828  2602          A     7,PPUPSG            ADD PRESENT PERIOD USAGE
0C2708 597C 4CCC            0C00C  2603          C     7,12(0,4)           DOES IT EXCEED MAX YR OUTPUT
0C27CC 472C 318A            0274A  2604       BH       CNPSGQ              IF YES, GO TO CNPSGQ
0C271C D203 2084 4CCC C3784 0C0C0  2605          MVC   POINT2(4),0(4)      SET POINT2 = Q(4)
0C2716 58F0 2C34            03734  2606          L     15,ASRDIST          FIND DISTANCE Q(4) TO WIP(5)
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2 STMT   SOURCE STATEMENT                                  F01AUG68  5/30/69

0C271A 05EF                       2607          BALR  14,15              ''
0C271C D203 20C4 20A4 C37C4 037A4 2608          MVC   TRANSD(4),DISTX    FIND TRANSPORTATION COST
CC2722 58FC 2038            03738 2609          L     15,ASRTRCST        ''
CC2726 05EF                       2610          BALR  14,15              ''
0C2728 5870 2CC8            037C8 2611          L     7,FIXPTCST         LOAD TRANS COST INTO REG7
0C272C 4A70 4014            00014 2612          AH    7,20(0,4)          ADD COST TO MINE & PROCESS
0C273C 4A70 402E            0002E 2613          AH    7,46(0,4)          ADD AMORTIZATION COST
0C2734 5970 3458            02A18 2614          C     7,LOWCOST          IS COST LOWER THAN PREVIOUS LOW
0C2738 472C 318A            0274A 2615          BH    CNPSGQ             IF NOT, GO TO CNPSGQ
0C273C 5070 3458            02A18 2616          ST    7,LOWCOST          STORE NEW LOW COST
0C274C 504C 2114            03814 2617          ST    4,QASSGNED         STORE ADDR Q ASSIGNED
CC2744 D203 211C 2C6C C3810 03760 2618          MVC   ADDRIP(4),MINONE   SET INTER POINT ADDR = -1
0C274A 584C 4034            00034 2619 CNPSGQ   L     4,52(0,4)          LOAD REG4 WITH ADDR NEXT Q IN CHAIN
CC274E 47FC 3CE4            026A4 2620          B     PSGLP              GO TO PSGLP
CC2752                            2621 QR4UIP   EQU   *                  (Q IN REG4 USES AN INTERMEDIATE PT)
0C2752 589C 2064            03764 2622          L     9,SQCH             LOAD REG9 WITH START Q CHAIN
CC2756                            2623 LFIPLP   EQU   *
0C2756 1299                       2624          LTR   9,9                ARE WE DONE LOOKING FOR IP'S
0C2758 474C 318A            0274A 2625          BM    CNPSGQ             IF YES, GO TO CNPSGQ
CC275C 915C 9CC5      CC005       2626          TM    5(9),X'50'         IS Q(9) A S&G Q AND AN IP
0C276C 47EC 3218            027D8 2627          BNO   LFNIP              IF NOT, GO TO LFNIP
0C2764 D5CC 4CC7 9CC7 CCCC7 0CC07 2628          CLC   7(1,4),7(9)        IS IT OWNED BY SAME OWNER AS Q(4)
0C276A 477C 3218            027D8 2629          BNE   LFNIP              IF NOT, GO TO LFNIP
0C276E 5870 904C            0CC4C 2630          L     7,76(0,9)          LOAD REG7 WITH MATL BEING USED TO DA
0C2772 5A7C 2128            03828 2631          A     7,PPUPSG           ADD PRESENT PERIOD USAGE
0C2776 597C 9CCC            0CC0C 2632          C     7,12(0,9)          DOES IT EXCEED MAX YR OUTPUT
CC277A 472C 3218            027D8 2633          BH    LFNIP              IF YES, GO TO LFNIP
0C277E D203 2CB4 9CCC C37B4 0CCC0 2634          MVC   POINT2(4),0(9)     SET POINT2 = Q(9)
CC2784 58FC 2034            03734 2635          L     15,ASRDIST         FIND DIST WIP(5) TO IP(9)
0C2788 C5EF                       2636          BALR  14,15              ''
CC278A D203 2CC4 2CA4 C37C4 037A4 2637          MVC   TRANSD(4),DISTX    FIND TRANSPORTATION COST
0C279C 58FC 2C38            03738 2638          L     15,ASRTRCST        ''
0C2794 C5EF                       2639          BALR  14,15              ''
0C2796 5870 2CC8            037C8 2640          L     7,FIXPTCST         LOAD REG7 WITH TRANS COST
CC279A D2C3 2CBC 4CCC C37B0 0CCC0 2641          MVC   POINT1(4),0(4)     SET POINT1 = Q(4)
0C27AC 58F0 2C34            03734 2642          L     15,ASRDIST         FIND DISTANCE IP(9) TO Q(4)
CC27A4 C5EF                       2643          BALR  14,15              ''
0C27A6 D203 2CBC 5CCC C37B0 0C0C0 2644          MVC   POINT1(4),0(5)     SET POINT1 = WIP(5)
0C27AC D2C3 2CC4 2CA4 C37C4 037A4 2645          MVC   TRANSD(4),DISTX    FIND TRANS COST
0C27B2 58FC 2C38            03738 2646          L     15,ASRTRCST        ''
CC27B6 C5EF                       2647          BALR  14,15              ''
0C27B8 5A7C 2CC8            037C8 2648          A     7,FIXPTCST         ADD TRANS COST TO REG7
0C27BC 4A70 902E            0C02E 2649          AH    7,46(0,9)          ADD AMORT COST AT Q(9)
CC27CC 4A7C 4C14            0C014 2650          AH    7,20(0,4)          ADD COST TO MINE & PROCESS AT Q(4)
CC27C4 5970 3458            02A18 2651          C     7,LOWCOST          IS COST LOWER THAN PREVIOUS LOW
0C27C8 472C 3218            027D8 2652          BH    LFNIP              IF NOT, GO TO LFNIP
0C27CC 504C 2114            03814 2653          ST    4,QASSGNED         STORE ADDR Q ASSIGNED
0C27DC 509C 211C            03810 2654          ST    9,ADDRIP           STORE ADDR INTER PT
0C27D4 507C 3458            02A18 2655          ST    7,LOWCOST          STORE NEW LOW COST
0C27D8 5890 9C34            00034 2656 LFNIP    L     9,52(0,9)          LOAD REG9 WITH ADDR NEXT Q IN CHAIN
CC27DC 47FC 3196            02756 2657          B     LFIPLP             GO TO LFIPLP
0C27EC                            2658 CHEKOUTS EQU   *                  (CHECK OUTSIDE QUARRIES)
0C27EC 5870 2CCC            0370C 2659          L     7,AOSQ             LOAD REG7 WITH ADDR OUTSIDE Q'S
0C27E4 C5C1 7CCC 2C6C CCCCC 03760 2660 OUTLPCK  CLC   0(2,7),MINONE      ARE WE DONE WITH OUTSIDE Q'S
0C27EA 478C 3298            02858 2661          BE    DONEOQ             IF YES, GO TO DONEOQ
0C27EE 438C 2405            03805 2662          IC    8,SUPPLIER         INSERT TYPE SUPPLIER INTO REG8
                                  2663 *                                 1=PSG, 2=UPSG, 4=CS
0C27F2 4480 328C            0284C 2664          EX    8,CTYPE            IS OUTSIDE Q THE CORRECT TYPE
0C27F6 477C 3284            02844 2665          BNE   CNOQ               IF NOT, GO TO CNOQ
0027FA 4386 5028            00028 2666          IC    8,40(6,5)          INSERT QUAL MATL REQ'D
0C27FE 448C 329C            02850 2667          EX    8,CQUALOS          IS OUTSIDE QUALITY O.K.
0028C2 47EC 3284            02844 2668          BNO   CNOQ               IF NOT, GO TO CNOQ
0028C6 D2C3 2CB4 7CC6 C37B4 0C006 2669          MVC   POINT2(4),6(7)     SET POINT2 = UNLD PT OUTSIDE Q(7)
0C28CC 58FC 2C34            03734 2670          L     15,ASRDIST         FIND DIST WIP(5) TO OUTSIDE Q
                                  2671 *                                 UNLOADING POINT
0C281C 05EF                       2672          BALR  14,15              ''
0C2812 D203 20C4 20A4 C37C4 037A4 2673          MVC   TRANSD(4),DISTX    FIND TRANS COST
CC2818 58FC 2C38            03738 2674          L     15,ASRTRCST        ''
0C281C 05EF                       2675          BALR  14,15              ''
0C281E 588C 2CC8            037C8 2676          L     8,FIXPTCST         LOAD REG8 WITH TRANS COST
0C2822 4A8C 7C04            0CC04 2677          AH    8,4(0,7)           ADD COST TO UNLD PT
CC2826 598C 3458            02A18 2678          C     8,LOWCOST          IS COST LOWER THAN PREVIOUS LOW
0C282A 4720 3284            02844 2679          BH    CNOQ               IF NOT, GO TO CNOQ
0C282E 508C 3458            02A18 2680          ST    8,LOWCOST          STORE NEW LOW COST
0C2832 5070 2114            03814 2681          ST    7,QASSGNED         STORE ADDR Q ASSGNED
0C2836 D203 211C 2C6C C3810 03760 2682          MVC   ADDRIP(4),MINONE   SET INTER PT ADDR = -1
CC283C 438C 2405            03805 2683          IC    11,SUPPLIER        LOAD SUPPLIER TYPE INTO REG11
CC284C 448C 3294            02854 2684          EX    11,SOTYPE          SET OUTSIDE TYPE
CC2844 417C 7C1C            00010 2685 CNOQ     LA    7,16(0,7)          LOAD REG7 WITH ADDR NEXT OUTSIDE Q
0C2848 47FC 3224            027E4 2686          B     OUTLPCK            GO TO OUTLPCK
0C284C 950C 7C02      CC002       2687 CTYPE    CLI   2(7),X'00'         IS Q THE CORRECT TYPE
0C285C 910C 7C03      CC003       2688 CQUALOS  TM    3(7),X'00'         IS QUALITY OUTSIDE O.K.
0C2854 92CC 24C6      C3BC6       2689 SOTYPE   MVI   OUTSI,X'00'        SET OUTSIDE TYPE
0C2858                            2690 DONEOQ   EQU   *                  (DONE OUTSIDE Q'S)
0C2858 588C 2114            03814 2691          L     8,QASSGNED         LOAD REG8 WITH ADDR ASSIGNED Q
0C285C 1288                       2692          LTR   8,8                WERE ANY Q'S ASSIGNED
00285E 474C 32AC            0286C 2693          BM    ENQAA              IF NOT, GO TO ENQAA
0C2862 58DC 3414            02904 2694          L     13,SAVLCQ+4
0C2866 98EC DC0C            0CC0C 2695          LM    14,12,12(13)
0C286A C7FE                       2696          BR    14
0C286C                            2697 ENQAA    EQU   *                  (ESTABLISH NEW QUARRY
0C286C D203 3458 213C C2A18 0383C 2698          MVC   LOWCOST(4),LARPOSN SET LOWCOST = LARGEST + NO.
002872 D203 2114 2C6C C3814 03760 2699          MVC   QASSGNED(4),MINONE SET ADDR ASSGNED Q = -1
0C2878 43B6 8028            00028 2700          IC    11,40(6,8)         SET INDEX REG 11 WITH TYPE Q
0C287C 5880 2068            03768 2701          L     8,SPQCH            LOAD REG, WITH START PQ CHAIN
CC288C 1288                       2702 AWDNQLP  LTR   8,8                ARE WE DONE LOOKINK FO PQ'S
0C2882 474C 333C            028FC 2703          BM    DLFNQ              IF YES, GO TO DLFNQ
0C2886 9508 21CC      C38CC       2704          CLI   INDEXT,X'08'       ARE WE LOOKING FOR CS Q
CC288A 4770 32DA            0289A 2705          BNE   NQRSG              IF NOT GO TO NQRSG
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                F01AUG68   5/30/69

0C288E 9120 8006      C0006       2706          TM    6(8),X'20'          DOES PQ(8) PRODUCE CRUSHED STONE
0C2892 47EC 32EA            028AA 2707          BNO   UPPQR8              IF NOT, GO TO UPPQR8
0C2896 47FC 32E2            028A2 2708          B     TYPEOK              OTHERWISE GO TO TYPEOK
0C289A 9140 8006      C0006       2709 NQRSG    TM    6(8),X'40'          IS IT A S&G PQ
0C289E 47EC 32EA            028AA 2710          BNO   UPPQR8              IF NOT, GO TO UPPQR8
0C28A2 448C 32F2            028B2 2711 TYPEOK   EX    11,TNQQ             IS QUALITY IN PQ(8) O.K.
0C28A6 4710 32F6            02886 2712          BO    NQOKTE              IF YES, GO TO NQOKTE
0C28AA 588C 8C34            00034 2713 UPPQR8   L     8,52(0,8)           LOAD REG8 WITH ADDR NEXT PQ IN CHAIN
0C28AE 47FC 32CC            02880 2714          B     AWDNQLP             GO TO AWDNQLP
0C2882 91C0 8017      C0017       2715 TNQQ     TM    23(8),X'00'         IS QUALITY OK
                                  2716 *  AT THIS POINT, PQ IN REG8 IS OK TO ESTABLISH.  WE MUST NOW TEST COST
0C2886 588C 8010            00010 2717 NQOKTE   L     11,16(0,8)          LOAD REG11 WITH ESTABLISHMENT COST
0C288A 1BAA                       2718          SR    10,10               CLEAR REG10
CC288C 5CA0 214C            03840 2719          M     10,HUNDRED          CONVERT EST COST TO PENNIES
0C28C0 5DAC 8CC8            0CC08 2720          D     10,8(0,8)           DIVIDE BY LIFE = AMORT COST
0C28C4 40BC 345C            02A1C 2721          STH   11,NQAC             STORE AMORT COST IN NQAC
0C28C8 D203 20B4 8CCC C3784 0C000 2722          MVC   POINT2(4),0(8)      SET POINT2 = ADDR PQ(8)
0C28CE 58FC 2C34            03734 2723          L     15,ASRDIST          FIND DISTANCE PQ(8) TO WIP(5)
0C28D2 05EF                       2724          BALR  14,15               ''
0C28D4 D203 20C4 2CA4 C37C4 037A4 2725          MVC   TRANSD(4),DISTX     FIND TRANSPORTATION COST
CC28DA 58FC 2C38            03738 2726          L     15,ASRTRCST         ''
0C28DE 05EF                       2727          BALR  14,15               ''
0C28EC 5ABC 20C8            037C8 2728          A     11,FIXPTCST         ADD TRANSPORTATION COST
0C28E4 4ABC 8C14            0C014 2729          AH    11,20(0,8)          ADD COST TO MINE & PROCESS
0C28E8 598C 3458            02A18 2730          C     11,LOWCOST          IS COST LOWER THAN PREVIOUS LOW
0C28EC 472C 32EA            028AA 2731          BH    UPPQR8              IF NOT, GO TO UPPQR8
                                  2732 *  AT THIS POINT, COST IS LOWER THAN PREVIOUS LOW COST
CC28FC 508C 3458            02A18 2733          ST    11,LOWCOST          STORE NEW LOW COST
CC28F4 508C 2114            03814 2734          ST    8,QASSGNED          STORE ADDR PQ(8)
0C28F8 47FC 32EA            028AA 2735          B     UPPQR8              GO TO UPPQR8
                                  2736 *  AT THIS POINT WE ARE FINISHED LOOKINK FOR A PQ
0C28FC                            2737 DLFNQ    EQU   *                   (DONE LOOKING FOR NEW QUARRY)
0C28FC 588C 2114            03814 2738          L     8,QASSGNED          LOAD REG8 WITH ADDR ASSGNED PQ
0C29CC 1288                       2739          LTR   8,8                 WERE ANY FOUND
0C29C2 4740 33C8            02988 2740          BM    NPQFABT             IF NOT, GO TO NPQFABT
0C29C6 508C 2098            03798 2741          ST    8,APQTBD            STORE ADDR PQ TO BE DELETED
0C29CA 58FC 2C28            03728 2742          L     15,ASRDPQ           DELETE IT FROM PQ CHAIN
0C29CE C5EF                       2743          BALR  14,15               ''
0C291C 9211 22C8      C39C8       2744          MVI   CARCONT,X'11'       WRITE MESSAGE
CC2914 D23C 22DD 25C7 C39DD 03C07 2745          MVC   OUTLINE+20(L'MDPQAQ),MDPQAQ   ''
0C291A 4888 CCCC            000C0 2746          LH    11,0(8)             ''
CC291E 4E8C 2CCC            037C0 2747          CVD   11,DW               ''
CC2922 DE03 22F6 2CC6 C39F6 03706 2748          ED    OUTLINE+45(4),DW+6  ''
CC2928 4888 CCC2            00C02 2749          LH    11,2(8)             ''
CC292C 4E8C 2CCC            03700 2750          CVD   11,DW
0C293C DE03 22FC 2CC6 C39FC 03706 2751          ED    OUTLINE+51(4),DW+6  ''
002936 D21C 231C 345E C3A1C 02A1E 2752          MVC   OUTLINE+83(L'MDR),MDR
0C293C 58F0 204C            0374C 2753          L     15,ALINEOUT         ''
0C294C 05EF                       2754          BALR  14,15
CC2942 94FE 8CC6      CCCC6       2755          NI    6(8),X'FE'          SET PQ = 0
0C2946 508C 2084            03784 2756          ST    8,AQTBA             STORE ADDR Q TO BE ADDED
0C294A 58FC 2C14            03714 2757          L     15,ASRAQ            ADD QUARRY
0C294E 05EF                       2758          BALR  14,15               ''
0C295C C201 802E 345C CC02E 02A1C 2759          MVC   46(2,8),NQAC        SET AMORTIZATION COST
CC2956 92CC 24C6      C3806       2760          MVI   OUTSI,X'00'         IT IS NOT FROM OUTSIDE
0C295A 95C0 21CC      C38CC       2761          CLI   INDEXT,X'00'        IS IT PROCESSED S&G
CC295E 478C 33B2            02972 2762          BE    SNQPSG              IF YES GO TO SNQPSG
0C2962 95C4 21CC      C38CC       2763          CLI   INDEXT,X'04'        IS IT UNPROCESSED S&G
CC2966 478C 33BA            0297A 2764          BE    SNQUPSG             IF YES, GO TOSNQUPSG
                                  2765 *  AT THIS POINT NEW QUARRY IS A CRUSHED STONE QUARRY
00296A 9223 8C05      CC0C5       2766          MVI   5(8),X'23'          SET Q(8) = CS Q
0C296E 47FC 33BE            0297E 2767          B     NQRET               GO TO NQRET
CC2972 9243 8CC5      CC0C5       2768 SNQPSG   MVI   5(8),X'43'          SET NEW Q = PROCESSED S&G
0C2976 47FC 33BE            0297E 2769          B     NQRET               GO TO NQRET
0C297A 9242 8C05      CC005       2770 SNQUPSG  MVI   5(8),X'42'          SET NEW Q = UNPROCESSED S&G
CC297E 58DC 3414            029D4 2771 NQRET    L     13,SAVLCQ+4         RETURN
0C2982 98EC DCCC            0C00C 2772          LM    14,12,12(13)        ''
0C2986 C7FE                       2773          BR    14                  ''
0C2988                            2774 NPQFABT  EQU   *                   (NONE FOUND, ABORT)
0C2988 D244 22DD 347C 039DD 02A3C 2775          MVC   OUTLINE+20(L'NFM),NFM   WRITE MESSAGE
00298E 58F0 204C            0374C 2776          L     15,ALINEOUT         ''
0C2992 05EF                       2777          BALR  14,15               ''
                                  2778          CLOSE (INDCB,,OUTDCB)
0C2994                            2779+         CNOP  0,4
0C2994 4510 33EC            029A0 2780+         BAL   1,*+12 BRANCH AROUND LIST
0C2998 C0                         2781+         DC    AL1(0) OPTION BYTE
002999 C008C4                     2782+         DC    AL3(INDCB) DCB ADDRESS
CC299C 80                         2783+         DC    AL1(128) OPTION BYTE
0C299D C009A4                     2784+         DC    AL3(OUTDCB) DCB ADDRESS
0C29AC 0A14                       2785+         SVC   20 ISSUE CLOSE SVC
CC29A2 58DC 3414            029D4 2786          L     13,SAVLCQ+4
CC29A6 98EC DC0C            0C00C 2787          LM    14,12,12(13)
                                  2788          REEXIT
0C29AA 181C                       2789+         LR    1,13
0C29AC 58DC DCC4            00004 2790+         L     13,4(,13)
0C29EC                            2791+         CNOP  0,4
0C29BC 47FC 33F8            029B8 2792+         B     *+8 BRANCH AROUND SP+LV
0029B4 C0                         2793+         DC    AL1(0) SUBPOOL VALUE
0C29B5 CCCC48                     2794+         DC    AL3(72) LENGTH
0029B8 58C0 33F4            029B4 2795+         L     0,*-4 LOAD SP AND LV
00298C CA0A                       2796+         SVC   10 ISSUE FREEMAIN SVC
00298E 98EC DC0C            0C00C 2797+         LM    14,12,12(13) RESTORE THE REGISTERS
0C29C2 92FF DCCC      CC0CC       2798+         MVI   12(13),X'FF' SET RETURN INDICATION
0C29C6 41FC CCCC            0C0C0 2799+         LA    15,0(0,0) LOAD RETURN CODE
0029CA 07FE                       2800+         BR    14 RETURN
0C29CC CCC029DC                   2801 ASAVLCQ  DC    A(SAVLCQ)
0C29DC                            2802 SAVLCQ   DS    18F
0C2A18                            2803 LOWCOST  DS    F
002A1C                            2804 NQAC     DS    H
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                             F01AUG68   5/30/69

0C2A1E C2C5C3C1E4E2C540             2805 MDR      DC    C'BECAUSE OF DEMAND REQUIREMENTS'
                                    2806 NFM      DC    C'NO QUARRIES OR POTENTIAL QUARRIES WERE FOUND TO MEET DX
0C2A3C D5D640D8E4C1D9D9                                 EMAND ... ABORT'
0C2A81                              2807 TYPMSK   DS    X
0C2A88                              2808          LTORG
                                    2809 ***********************************************************************
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                        F01AUG68   5/30/69

                                   2811          ENTRY SRPQCOST
002A88                             2812 MINEINPT CSECT                      (INPUT CONTROL SECTION)
000004                             2813 RPOINTER EQU   4
                                   2814          REENTER BASE=12
002A88                             2815+         USING *,12
002A88                             2816+         DS    0H
002A88 90EC D00C            0000C  2817+         STM   14,12,12(13) SAVE REGISTERS
002A8C 18CF                        2818+         LR    12,15
002A8E 0700                        2819+         CNOP  0,4
002A90 4510 C010            02A98  2820+         BAL   1,*+8 BRANCH AROUND SP+LV
002A94 00                          2821+         DC    AL1(0) SUBPOOL VALUE
002A95 000048                      2822+         DC    AL3(72) LENGTH
002A98 5801 0000            00000  2823+         L     0,0(1,0) LOAD SP AND LV
002A9C 0A0A                        2824+         SVC   10 ISSUE GETMAIN SVC
002A9E 5010 D008            00008  2825+         ST    1,8(,13)
002AA2 50D0 1004            00004  2826+         ST    13,4(,1)
002AA6 18FD                        2827+         LR    15,13
002AA8 18D1                        2828+         LR    13,1
002AAA 98F1 F010            00010  2829+         LM    15,1,16(15)
002AAE 5820 2008            03708  2830          L     2,ACOMMON           LOAD REG2 WITH ADDR COMMON AREA
003700                             2831          USING COMMON,2
                                   2832          OPEN  (INDCB,,OUTDCB,(OUTPUT))
002AB2 0700                        2833+         CNOP  0,4
002AB4 4510 C038            02AC0  2834+         BAL   1,*+12 LOAD REG1 W/LIST ADDR.
002AB8 00                          2835+         DC    AL1(0) OPTION BYTE
002AB9 0008C4                      2836+         DC    AL3(INDCB) DCB ADDRESS
002ABC 8F                          2837+         DC    AL1(143) OPTION BYTE
002ABD 0009A4                      2838+         DC    AL3(OUTDCB) DCB ADDRESS
002AC0 0A13                        2839+         SVC   19 ISSUE OPEN SVC
002AC2 928B 22C8      039C8        2840          MVI   CARCONT,X'8B'        SKIP TO TOP OF PAGE
002AC6 58F0 204C            0374C  2841          L     15,ALINEOUT          ''
002ACA 05EF                        2842          BALR  14,15                ''
002ACC 9219 22C8      039C8        2843          MVI   CARCONT,X'19'        WRITE & SPACE 3
002AD0 D227 22D3 C9D0 039D3 03458  2844          MVC  OUTLINE+10(L'INMES),INMES  PRINT HEADING
002AD6 58F0 204C            0374C  2845          L     15,ALINEOUT          ''
002ADA 05EF                        2846          BALR  14,15                ''
002ADC 9200 C9A2      0342A        2847          MVI   ERRORS,X'00'         SET ERRORS INDICATOR = 0
002AE0 1B77                        2848          SR    7,7                 CLEAR REG7
002AE2 5070 2154            03854  2849          ST    7,CCPSG             SET CUMULATIVE COST PSG =0
002AE6 5070 2158            03858  2850          ST    7,CCUPSG                       ''       UPSG =0
002AEA 5070 215C            0385C  2851          ST    7,CCCS                         ''       CS =0
002AEE 5070 2160            03860  2852          ST    7,CTMPSG            SET CUMULATIVE TON-MILES PSG =0
002AF2 5070 2164            03864  2853          ST    7,CTMUPSG                          ''        UPSG =0
002AF6 5070 2168            03868  2854          ST    7,CTMCS                            ''        CS =0
002AFA 5070 216C            0386C  2855          ST    7,CTPSG             SET CUMULATIVE TONS PSG =0
002AFE 5070 2170            03870  2856          ST    7,CTUPSG                       ''       UPSG =0
002B02 5070 2174            03874  2857          ST    7,CTCS                         ''       CS =0
002B06 5070 2178            03878  2858          ST    7,CMWTD             SET CUMULATIVE MATL WASTED IN Q =0
002B0A 5070 217C            0387C  2859          ST    7,CMWTDPQ           SET CUMULATIVE MATL WASTED IN PQ =0
002B0E 5070 2180            03880  2860          ST    7,TOTMATLW          SET TOTAL MATL WASTED =0
002B12 5070 2184            03884  2861          ST    7,TOTCOST           SET TOTAL COST =0
002B16 5070 2188            03888  2862          ST    7,TOTTM             SET TOTAL TON-MILES =0
002B1A 5070 218C            0388C  2863          ST    7,TOTTONS           SET TOTAL TONS =0
002B1E 5070 2190            03890  2864          ST    7,CTRCST            SET CUMULATIVE TRANSPORT COST =0
002B22 5070 2194            03894  2865          ST    7,CTONSOUT          SET CUMULATIVE TONS FROM OUTSIDE =0
002B26 5070 2198            03898  2866          ST    7,CCOUTS            SET CUMULATIVE COST FROM OUTSIDE =0
                                   2867 *
002B2A 58F0 2048            03748  2868          L     15,ACARDIN          READ OPTION CARD
002B2E 05EF                        2869          BALR  14,15               ''
                                   2870 *  THIS SECTION READS THE OPTION CARD
002B30 F271 2C00 2277 03700 03977  2871          PACK  DW(8),INPUT(2)          PACK MAXYEAR
002B36 960F 2C07      03707        2872          OI    DW+7,X'0F'
002B3A 4FB0 2C00            03700  2873          CVB   11,DW
002B3E 42B0 2266            03966  2874          STC   11,MAXYEAR              STORE MAXYEAR
002B42 F270 2C00 2279 03700 03979  2875          PACK  DW(8),INPUT+2(1)        PACK ASSGNQ
002B48 960F 2C07      03707        2876          OI    DW+7,X'0F'
002B4C 4FB0 2C00            03700  2877          CVB   11,DW
002B50 42B0 2267            03967  2878          STC   11,ASSGNQ               STORE ASSGNQ
002B54 D200 226C 227A 0396C 0397A  2879          MVC   PQINFO(1),INPUT+3       STORE PQINFO
002B5A F271 2C00 227B 03700 0397B  2880          PACK  DW(8),INPUT+4(2)        PACK PLANNING HORIZON
002B60 960F 2C07      03707        2881          OI    DW+7,X'0F'
002B64 4FB0 2C00            03700  2882          CVB   11,DW
002B68 42B0 226A            0396A  2883          STC   11,PLANHORZ             STORE PLANHORZ
002B6C D200 23F8 227D 03AF8 0397D  2884          MVC   ZLAW(1),INPUT+6         PREPARE ZONE LAW = NO ZONING
                                   2885          CALL  SETZL
002B72 0700                        2886+         CNOP  0,4
002B74 47F0 C0F4            02B7C  2887+         B     *+8 BRANCH AROUND VCON
002B78 00000000                    2888+IHB0031B DC    V(SETZL) ENTRY POINT ADDRESS
002B7C 58F0 C0F0            02B78  2889+         L     15,IHB0031B LOAD 15 WITH ENTRY ADR
002B80 05EF                        2890+         BALR  14,15 BRANCH TO ENTRY POINT
002B82 D200 226B 23F9 0396B 03AF9  2891          MVC   ZLNOZONE(1),ZLAWD       STORE ZLNOZONE
002B88 F273 2C00 227E 03700 0397E  2892          PACK  DW(8),INPUT+7(4)
002B8E 960F 2C07      03707        2893          OI    DW+7,X'0F'
002B92 4FB0 2C00            03700  2894          CVB   11,DW
002B96 50B0 2258            03958  2895          ST    11,HGCONF               STORE IN HGCONF
002B9A 9646 2258      03958        2896          OI    HGCONF,X'46'            CONVERT TO FLT PT
002B9E 7820 2258            03958  2897          LE    2,HGCONF                LOAD INTO FLT PT REG2
002BA2 7D20 CA10            03498  2898          DE    2,=E'100'               DIVIDE BY 100
002BA6 7020 2258            03958  2899          STE   2,HGCONF                STORE HGCONF
002BAA F273 2C00 2282 03700 03982  2900          PACK  DW(8),INPUT+11(4)       PACK VERTICAL GRID CONVERSION
002BB0 960F 2C07      03707        2901          OI    DW+7,X'0F'
002BB4 4FB0 2C00            03700  2902          CVB   11,DW
002BB8 50B0 225C            0395C  2903          ST    11,VGCONF
002BBC 9646 225C      0395C        2904          OI    VGCONF,X'46'            CONVERT TO FLT PT
002BC0 7820 225C            0395C  2905          LE    2,VGCONF                LOAD INTO FLT PT REG2
002BC4 7D20 CA10            03498  2906          DE    2,=E'100'               DIVIDE BY 100
002BC8 7020 225C            0395C  2907          STE   2,VGCONF                STORE VGCONF
002BCC F273 2C00 2286 03700 03986  2908          PACK  DW(8),INPUT+15(4)       PACK ST LINE CONF FACTOR
002BD2 960F 2C07      03707        2909          OI    DW+7,X'0F'
```

```
  LOC  OBJECT CCDE    ADDR1 ACDR2  STMT   SOURCE STATEMENT                                              F01AUG68   5/30/69

002BCE 4FB0 2CC0            03700  2910          CVB   11,DW
0C2BCA 50B0 226C            03960  2911          ST    11,SLCONF
0C2BDE 9646 2260      C3960        2912          OI    SLCONF,X'46'            CONVERT TO FLT PT
0C2BE2 782C 226C            03960  2913          LE    2,SLCONF                LOAD INTO FLT PT REG2
0C2BE6 7D20 CA10            03498  2914          DE    2,=E'100'               DIVIDE BY 100
0C2BEA 7020 2260            03960  2915          STE   2,SLCONF                STORE SL CONF
0C2BEE 95F1 228A      C398A        2916          CLI   INPUT+19,X'F1'     DOES A ONLY REQ PROCESSING
0C2BF2 4780 C182            02C0A  2917          BE    AONLYF             IF YES, GO TO AONLYF
0C2BF6 95F2 228A      0398A        2918          CLI   INPUT+19,X'F2'     DOES B OR BETTER REQUIRE PROCESSING
0C2BFA 478C C18A            02C12  2919          BE    BORBF              IF YES GO TO BORBF
0C2BFE 95F3 228A      0398A        2920          CLI   INPUT+19,X'F3'     DOES C OR BETTER REQUIRE PROCESSING
0C2CC2 4780 C192            02C1A  2921          BE    CORBF              IF YES GO TO COBEF
0C2CC6 47FC C19A            02C22  2922          B     DORBF              OTHERWISE GO TO DORBF
CC2CCA 9201 2268      0396B        2923 AONLYF   MVI   DFAREQPR,X'01'     SET A ONLY MASK
CC2CCE 47FC C19E            02C26  2924          B     TCAGG              GO TO TCAGG
0C2C12 9203 2268      03968        2925 BORBF    MVI   DFAREQPR,X'03'     SET B OR BETTER MASK
CC2C16 47FC C19E            02C26  2926          B     TCAGG              GO TO TCAGG
0C2C1A 9207 2268      C3968        2927 CORBF    MVI   DFAREQPR,X'07'     SET C OR BETTER MASK
CC2C1E 47FC C19E            02C26  2928          B     TCAGG              GO TO TCAGG
0C2C22 920F 2268      03968        2929 DORBF    MVI   DFAREQPR,X'0F'     SET D OR BETTER MASK
0C2C26 95F1 228B      C398B        2930 TCAGG    CLI   INPUT+20,X'F1'     DOES A ONLY REQ PROCESSING
0C2C2A 478C C1CA            02C52  2931          BE    AONLYC             IF YES GO TO AONLYC
002C2E 95F2 228B      0398B        2932          CLI   INPUT+20,X'F2'     DOES B OR BETTER REQUIRE PROCESSING
0C2C32 4780 C1D2            02C5A  2933          BE    BORBC              IF YES, GO TO BORBC
CC2C36 95F3 228B      C398B        2934          CLI   INPUT+20,X'F3'     DOES C OR BETTER REQUIRE PROCESSING
CC2C3A 478C C1DA            02C62  2935          BE    CORBC              IF YES GO TO CORBC
0C2C3E 95F4 228B      C398B        2936          CLI   INPUT+20,X'F4'     DOES D OR BETTER REQUIRE PODCESSING
CC2C42 478C C1E2            02C6A  2937          BE    DORBC              IF YES, GO TO DORBC
0C2C46 95F5 228B      C398B        2938          CLI   INPUT+20,X'F5'     DOES I3 OR BETTER REQUIRE PROCESSING
0C2C4A 4780 C1EA            02C72  2939          BE    I3ORBC             IF YES, GO TO I3ORBC
0C2C4E 47FC C1F2            02C7A  2940          B     I4ORBC             OTHERWISE, GO TO I4ORBC
CC2C52 92C1 2269      C3969        2941 AONLYC   MVI   DCAREQPR,X'01'     SET A ONLY MASK
CC2C56 47FC C1F6            02C7E  2942          B     DAGG               GO TO DAGG
CC2C5A 92C3 2269      C3969        2943 BORBC    MVI   DCAREQPR,X'03'     SET B OR BETTER MASK
CC2C5E 47F0 C1F6            02C7E  2944          B     DAGG               GO TO DAGG
0C2C62 92C7 2269      C3969        2945 CORBC    MVI   DCAREQPR,X'07'     SET C OR BETTER MASK
0C2C66 47FC C1F6            02C7E  2946          B     DAGG               GO TO DAGG
0C2C6A 920F 2269      C3969        2947 DORBC    MVI   DCAREQPR,X'0F'     SET D OR BETTER MASK
0C2C6E 47FC C1F6            02C7E  2948          B     DAGG               GO TO DAGG
0C2C72 921F 2269      C3969        2949 I3ORBC   MVI   DCAREQPR,X'1F'     SET I3 OR BETTER MASK
CC2C76 47FC C1F6            02C7E  2950          B     DAGG               GO TO DAGG
0C2C7A 923F 2269      C3969        2951 I4ORBC   MVI   DCAREQPR,X'3F'     SET I4 OR BETTER MASK
CC2C7E                             2952 DAGG     EQU   *
0C2C7E F273 2CCC 228C C37C0 0398C  2953          PACK  DW(8),INPUT+21(4)        PACK TRANS COST INTERCEPT
0C2C84 960F 2CC7      C37C7        2954          OI    DW+7,X'0F'
CC2C88 4FBC 2CCC            037C0  2955          CVB   11,DW
0C2C8C 40BC 2264            03964  2956          STH   11,COSTINT         STORE TRANS COST INTERCEPT
0C2C9C F271 2CCC 229C C37C0 03990  2957          PACK  DW(8),INPUT+25(2)  PACK LIFE NEW PROCESSING PLANT
0C2C96 96CF 2CC7      C37C7        2958          OI    DW+7,X'0F'
CC2C9A 4FBC 2CCC            037C0  2959          CVB   11,DW
0C2C9E 42BC 2407            03807  2960          STC   11,LNPP
CC2CA2 F272 2C00 2292 C37C0 03992  2961          PACK  DW(8),INPUT+27(3)    PACK PER CENT UN PR S&G FROM Q
CC2CA8 960F 2CC7      C37C7        2962          OI    DW+7,X'0F'
CC2CAC 4FBC 2CCC            03700  2963          CVB   11,DW
0C2CBC 5CB0 21DC            038D0  2964          ST    11,PERCFQ
                                   2965 *  THIS SECTION READS THE THREE CARDS CONTAINING THE TRANSPORTATION
                                   2966 *   CCST CURVE
CC2CB4 58FC 2048            0374B  2967          L     15,ACARDIN         READ CARD 1
0C2CB8 05EF                        2968          BALR  14,15              ''
CC2CBA D24D 2578 2277 C3C78 03977  2969          MVC   MATRIX(78),INPUT   MOVE TO MATRIX
0C2CCC 05EF                        2970          BALR  14,15              READ CARD 2
0C2CC2 D24C 25C6 2277 C3CC6 03977  2971          MVC   MATRIX+78(78),INPUT MOVE TO MATRIX + 78
0C2CC8 05EF                        2972          BALR  14,15              READ CARD 3
CC2CCA D223 2614 2277 C3D14 03977  2973          MVC   MATRIX+156(36),INPUT
CC2CCC 1877                        2974          SR    7,7                CLEAR REG7
0C2CD2 586C 201C            03710  2975          L     6,AMATRIX          LOAD REG6 WITH ADDR MATRIX
CC2CD6 F272 2CCC 6CCC 037C0 0CCC0  2976 PNCOST   PACK  DW(8),0(3,6)       PACK TRANSPORTATION COST
0C2CDC 960F 2CC7      C3707        2977          OI    DW+7,X'0F'         MAKE BLANK = 0
0C2CEC 4FBC 2CCC            037C0  2978          CVB   11,DW              CONVERT COST TO BINARY
0C2CE4 4087 2104            038C4  2979          STH   11,TRCOST(7)       STORE AT CORRECT LOCATION IN TRCOST
0C2CE8 417C 7CC2            0CC02  2980          LA    7,2(0,7)           ADD 2 TO REG7
0C2CEC 4970 CA18            034A0  2981          CH    7,=H'128'          ARE WE DONE WITH TRANSPORT CURVE
0C2CFC 478C C274            02CFC  2982          BE    DONWTRC            IF YES GO TO DONWTRC
0C2CF4 416C 6CC3            0CC03  2983          LA    6,3(0,6)           OTHERWISE, ADD 3 TO REG6
0C2CF8 47FC C24E            02CD6  2984          B     PNCOST             AND GO TO PNCOST
0C2CFC                             2985 DONWTRC  EQU   *
                                   2986 *
0C2CFC 5840 2C0C            0370C  2987          L     RPOINTER,ADSQ      LOAD RPOINTER WITH ADDR OUTSIDE Q
0C2DCC                             2988 READOUTQ EQU   *                  (READ OUTSIDE GRIDS)
CC2DCC 58FC 2048            03748  2989          L     15,ACARDIN         CALL INPUT ROUTINE
0C2DC4 05EF                        2990          BALR  14,15              ''
0C2DC6 D501 2277 2275 C3977 03975  2991          CLC   INPUT(2),STARSTAR  COMPARE FOR END OF DATA SET **
0C2DCC 4780 C316            02D9E  2992          BE    READGRID
0C2D1C F272 2CCC 2277 C3700 03977  2993          PACK  DW(8),INPUT(3)     PACK OUTSIDE Q NUMBER
0C2D16 980F 2C07      03707        2994          OI    DW+7,X'0F'
0C2D1A 4FBC 2CCC            03700  2995          CVB   11,DW
0C2D1E 40B0 4CC0            0C0C0  2996          STH   11,0(0,RPOINTER)
002C22 95F3 227A      0397A        2997          CLI   INPUT+3,X'F3'      IS IT A PSG Q
002D26 4780 C2B2            02D3A  2998          BE    SETOPSG            IF YES GO TO SETOPSG
002D2A 95F2 227A      C397A        2999          CLI   INPUT+3,X'F2'      IS IT AN UN PROCESSED S&G Q
0C2D2E 478C C2BA            02D42  3000          BE    SETOUPSG           IF YES, GO TO SETOUPSG
002D32 92C4 4C02      C0002        3001          MVI   2(RPOINTER),X'04'  SET TYPE = CRUSHED STONE = 00000100
002D36 47FC C2BE            02D46  3002          B     SOQUAL             GO TO SOQUAL
002B3A 9201 4002      C0002        3003 SETOPSG  MVI   2(RPOINTER),X'01'  SET TYPE = PROCESSED S&G = 00000001
0C2D3E 47F0 C2BE            02D46  3004          B     SOQUAL             GO TO SOQUAL
002D42 9202 4C02      00002        3005 SETOUPSG MVI   2(RPOINTER),X'02'  SET TYPE = UNPROCESSED S&G =00000010
002D46                             3006 SOQUAL   EQU   *
002D46 D200 23F4 2278 03AF4 0397B  3007          MVC   QCA(1),INPUT+4     SET OUTSIDE QUALITY
                                   3008          CALL  SETQUAL            SET OUTSIDE QUALITY
```

```
  LCC  OBJECT CCDE     ADDR1 ACDR2  STMT   SOURCE STATEMENT                                              F01AUG68   5/30/69

0C2C4C                              3009+          CNOP  0,4
CC2C4C 47FC C2CC              02D54 3010+          B     *+8 BRANCH AROUND VCON
0C2C5C CCCCCCCC                     3011*IHB00328  DC    V(SETQUAL) ENTRY POINT ADDRESS
0C2C54 58FC C2C8              02D50 3012+          L     15,IHB00328 LOAD 15 WITH ENTRY ADR
0C2C58 05FF                         3013+          BALR  14,15 BRANCH TO ENTRY POINT
CC2C5A D2CC 4CC3 23F5 CC0C3 03AF5   3014           MVC   3(1,RPOINTER),QCAD  ''
CC2C6C F273 2CCC 227C C37C0 0397C   3015           PACK  DW(8),INPUT+5(4)    PACK TOTAL COST TO UNLD PT
CC2C66 98CF 2CC7      C3707         3016           OI    DW+7,X'OF'
CC2C6A 4FBC 2CCC              037C0 3017           CVB   11,DW
CC2C6E 40BC 4CC4              0CCC4 3018           STH   11,4(0,RPOINTER)
CC2C72 F272 2CC0 2280 C37C0 03980   3019           PACK  DW(8),INPUT+9(3)    PACK ROW UNLD PT
CC2C78 960F 2CC7      C37C7         3020           OI    DW+7,X'OF'
CC2C7C 4FBC 2CCC              037C0 3021           CVB   11,DW
CC2C8C 40BC 4CC6              0C006 3022           STH   11,6(0,RPOINTER)
0C2C84 F272 2CCC 2283 C37C0 03983   3023           PACK  DW(8),INPUT+12(3)   PACK COL UNLD PT
CC2C8A 960F 2CC7      C3707         3024           OI    DW+7,X'OF'
CC2C8E 4FBC 2CCC              037C0 3025           CVB   11,DW
0C2C92 40BC 4C08              0C0C8 3026           STH   11,8(0,RPOINTER)
0C2C96 414C 4C1C              0C010 3027           LA    RPOINTER,16(0,RPOINTER) ADD 16 TO RPOINTER
0C2C9A 47FC C278              02DC0 3028           B     READOUTQ            GO TO READ OUTSIDE QUARRY CARD
CC2C9E                              3029 READGRID  EQU   *
CC2C9F C201 4CCC 2C6C CCCC0 03760   3030           MVC   0(2,RPOINTER),MINONE    SET LAST Q INDICATOR = -1
CC2CA4 584C 2C1C              03710 3031           L     RPOINTER,AMATRIX    LOAD POINTER WITH ADDR OF MATRIX
CC2CA8                              3032 READCARD  EQU   *                   (READ CARD)
CC2CA8 58FC 2C48              03748 3033           L     15,ACARDIN          CALL INPUT ROUTINE
CC2CAC C5EF                         3034           BALR  14,15               ''
CC2CAE D5C1 2277 2275 C3977 03975   3035           CLC   INPUT(2),STARSTAR   COMPARE FOR END DATA SET CARD **
CC2CB4 478C C724              031AC 3036           BE    ALLCDSRD            IF SO, GO TO ALL CARDS READ
CC2CB8 D202 C9A3 2277 C342B 03977   3037           MVC   TEMPR(3),INPUT       MOVE ROW TO TEMPR
CC2CBE D202 C9A6 227A C342E 0397A   3038           MVC   TEMPC(3),INPUT+3     MOVE COL TO TEMPC
CC2CC4 1BAA                         3039           SR    10,10               CLEAR REG10
CC2CC6 F272 2CCC 2277 C37C0 03977   3040           PACK  DW(8),INPUT(3)      PACK ROW
CC2CCC 96CF 2CC7      C3707         3041           OI    DW+7,X'OF'          MAKE NUMBER A LEGAL POSITIVE
CC2CCC 4FBC 2CCC              037C0 3042           CVB   11,DW               CONVERT ROW TO BINARY
CC2CD4 40BC 4CCC              0C0C0 3043           STH   11,0(0,RPOINTER)    STORE ROW AT ADDRESS IN RPOINTER
CC2CD8 F272 2CCC 227A C37C0 0397A   3044           PACK  DW(8),INPUT+3(3)    PACK COL
CC2CDE 960F 2CC7      C37C7         3045           OI    DW+7,X'OF'          MAKE NUMBER A LEGAL POSITIVE
CC2CE2 4FBC 2CCC              037C0 3046           CVB   11,DW
CC2CE6 4CBC 4CC2              0C0C2 3047           STH   11,2(0,RPOINTER)
CC2CEA C2CC 23F8 227C C3AF8 0397D   3048           MVC   ZLAW(1),INPUT+6     MOVE ZONING LAW  TO ZLAW
                                    3049           CALL  SETZL               SET ZONING LAW CONFIGURATION
CC2CFC                              3050+          CNOP  0,4
CC2CFC 47FC C37C              02DF8 3051+          B     *+8 BRANCH AROUND VCON
0C2CF4 CCCCCCCC                     3052+IHB00338  DC    V(SETZL) ENTRY POINT ADDRESS
CC2CF8 58FC C36C              02DF4 3053+          L     15,IHB00338 LOAD 15 WITH ENTRY ADR
CC2CFC C5EF                         3054+          BALR  14,15 BRANCH TO ENTRY POINT
CC2CFE C2CC 4C04 23F9 CCCC4 03AF9   3055           MVC   4(1,RPOINTER),ZLAWD MOVE ZONING LAW INTO RPOINTER+4
CC2EC4 F27C 2CCC 227E C37CC 0397E   3056           PACK  DW(8),INPUT+7(1)    PACK IOCC
CC2ECA 98CF 2CC7      C37C7         3057           OI    DW+7,X'OF'          MAKE NUMBER A LEGAL POSITIVE
CC2ECE 4FBC 2CCC              037C0 3058           CVB   11,DW               .
0C2E12 42BC 4C2C              0CC2C 3059           STC   11,45(0,RPOINTER)
CC2E16 96FC 2283      C3983         3060           OI    INPUT+12,X'F0'      MAKE POSSIBLE BLANK A 0
CC2E1A F27C 2CCC 227F C37CC 0397F   3061           PACK  DW(8),INPUT+8(1)    PACK IQ
CC2F2C 96CF 2CC7      C37C7         3062           OI    DW+7,X'OF'          MAKE NUMBER A LEGAL POSITIVE
0C2E24 4FBC 2CCC              037C0 3063           CVB   11,DW
CC2E2F 42BC 4CC5              0C005 3064           STC   11,5(0,RPOINTER)
CC2E2C 9103 4C05      CCCC5         3065           TM    5(RPOINTER),X'03'   IS IT A QUARRY
CC2E3C 478C C3FC              02E78 3066           BZ    PACKIPQ             IF NOT, GO TO PACK IPQ
CC2E34 92CC 4CC6      CCCC6         3067           MVI   6(RPOINTER),X'00'    SET PQ = 0
                                    3068 *  AT THIS POINT IT IS A QUARRY, WE MUST NOW DETERMINE TYPE
CC2E38 95F1 2283      C3983         3069           CLI   INPUT+12,X'F1'      IS IT A CRUSHED STONE QUARRY
CC2E3C 478C C3E8              02E70 3070           BE    SETMSK20            IF YES, GO TO SETMSK20
CC2E4C 95F2 2283      C3983         3071           CLI   INPUT+12,X'F2'      IS IT A S&G QUARRY
CC2E44 4780 C3EC              02E68 3072           BE    SETMSK40            IF YES GO TO SETMSK40
CC2E48 95F3 2283      03983         3073           CLI   INPUT+12,X'F3'      IS IT A S&G Q AND AN IP
CC2E4C 4780 C3D8              02E60 3074           BE    SETMSK50            IF YES GO TO SETMSK50
CC2E5C 95F4 2283      C3983         3075           CLI   INPUT+12,X'F4'      IS IT A S&G Q USING AN IP
CC2E54 477C C97E              03406 3076           BNE   INCARERR            IF NOT, GO TO INCARERR
CC2E58 9644 4CC5      CC0C5         3077           OI    5(RPOINTER),X'44'   IT IS A S&G AND USES AN IP
CC2F5C 47FC C426              02EAE 3078           B     PACKOWNR            GO TO PACK OWNR
CC2E6C 965C 4CC5      CC0C5         3079 SETMSK50  OI    5(RPOINTER),X'50'   IT IS A S&G Q AND AN IP
CC2E64 47FC C426              02EAE 3080           B     PACKOWNR            GO TO PACK OWNR
CC2E6P 964C 4CC5      CC0C5         3081 SETMSK40  OI    5(RPOINTER),X'40'   IT IS A S&G Q, NOT AN IP, NOT USING
CC2E6C 47FC C426              02EAE 3082           B     PACKOWNR            GO TO PACK OWNR
0C2E7C 962C 4CC5      CC0C5         3083 SETMSK20  OI    5(RPOINTER),X'20'   IT IS A CS QUARRY
CC2E74 47FC C426              02EAE 3084           B     PACKOWNR            GO TO PACK OWNR
CC2E78                              3085 PACKIPQ   EQU *
CC2E78 F27C 2CCC 228C 037C0 03980   3086           PACK  DW(8),INPUT+9(1)    PACK IPQ
0C2E7E 960F 2CC7      C37C7         3087           OI    DW+7,X'OF'          MAKE NUMBER A LEGAL POSITIVE
0C2E82 4FBC 2C0C              03700 3088           CVB   11,DW
0C2E86 42BC 4C06              0C006 3089           STC   11,6(0,RPOINTER)
0C2E8A 9101 4CC6      CCCC6         3090           TM    6(RPOINTER),X'01'   IS IT A PQ
CC2E8E 4780 C426              02EAE 3091           BZ    PACKOWNR            IF NOT GO TO PACK OWNER
                                    3092 *  AT THIS POINT IT IS A PQ, WE MUST NOW DETERMINE TYPE
002E92 95F1 2283      03983         3093           CLI   INPUT+12,X'F1'      IS IT A CRUSHED STONE PQ
0C2E96 478C C422              02EAA 3094           BE    SETPQM20            IF YES, GO TO SETPQM20
0C2E9A 95F2 2283      C3983         3095           CLI   INPUT+12,X'F2'      IS IT A S&G PQ
CC2E9E 477C C97E              03406 3096           BNE   INCARERR            IF NOT, GO TO INCARERR
0C2EA2 9640 4C06      CC006         3097           OI    6(RPOINTER),X'40'   SET PQ TO A S&G PQ
0C2EA6 47FC C426              02EAE 3098           B     PACKOWNR            GO TO PACKOWNR
0C2EAA 962C 4C06      C0006         3099 SETPQM20  OI    6(RPOINTER),X'20'   SET PQ TO A CS PQ
0C2EAE                              3100 PACKOWNR  EQU   *
0C2EAE F271 2C00 2281 C3700 03981   3101           PACK  DW(8),INPUT+10(2)   PACK OWNER
0C2EB4 960F 2CC7      C3707         3102           OI    DW+7,X'OF'
0C2EB8 4FBC 2CCC              03700 3103           CVB   11,DW
0C2EBC 42BC 4C07              00007 3104           STC   11,7(0,RPOINTER)
0C2ECC F272 2C0C 2284 03700 03984   3105           PACK  DW(8),INPUT+13(3)   PACK PERCENT SAND (IF S&G)
0C2EC6 960F 2007      C3707         3106           OI    DW+7,X'OF'
0C2ECA 4FBC 2CCC              03700 3107           CVB   11,DW
```

```
 LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                        F01AUG68   5/30/69

0C2ECE 42BC 4018            00018  3108          STC   11,24(0,RPOINTER)
0C2ED2 D2CC 23F4 2287 C3AF4 03987  3109          MVC   QCA(1),INPUT+16     DETERMINE QUALITY FINE AGGREGATE
                                   3110          CALL  SETQUAL             SET QUALITY
0C2ED8                             3111+         CNOP  0,4
0C2ED8 47FC C458            02EE0  3112+         B     *+8 BRANCH AROUND VCON
0C2EDC CCCC0CC0                    3113+IHB0034B DC    V(SETQUAL) ENTRY POINT ADDRESS
0C2EEC 58F0 C454            02EDC  3114+         L     15,IHB0034B LOAD 15 WITH ENTRY ADR
0C2EE4 05EF                        3115+         BALR  14,15 BRANCH TO ENTRY POINT
0C2EE6 D2CC 4016 23F5 C0016 03AF5  3116          MVC   22(1,RPOINTER),QCAD MOVE QUALITY TO RPOINTER+22
0C2EEC D2C0 23F4 2288 C3AF4 03988  3117          MVC   QCA(1),INPUT+17     DETERMINE QUALITY COARSE AGGREGATE
                                   3118          CALL  SETQUAL             SET QUALITY
CC2EF2 070C                        3119+         CNOP  0,4
0C2EF4 47FC C474            02EFC  3120+         B     *+8 BRANCH AROUND VCON
CC2EF8 CCCCCCCC                    3121+IHB0035B DC    V(SETQUAL) ENTRY POINT ADDRESS
CC2EFC 58FC C47C            02EF8  3122+         L     15,IHB0035B LOAD 15 WITH ENTRY ADR
CC2FCC C5EF                        3123+         BALR  14,15 BRANCH TO ENTRY POINT
CC2FC2 D2CC 4C17 23F5 C0017 03AF5  3124          MVC   23(1,RPOINTER),QCAD MOVE QUALITY TO RPOINTER+23
0C2F08 F273 2CCC 2289 C37C0 03989  3125          PACK  DW(8),INPUT+18(4)   PACK E(LIFE)
0C2FCE 960F 2CC7      C37C7        3126          OI    DW+7,X'OF'          MAKE NUMBER A LEGAL POSITIVE
0C2F12 4FBC 2CC0            037C0  3127          CVB   11,DW
CC2F16 1BAA                        3128          SR    10,10               CLEAR REG10
CC2F18 5CAC 2144            03844  3129          M     10,THOUSAND         MULTIPLY BY 1000
0C2F1C 50BC 4C08            0C008  3130          ST    11,8(0,RPOINTER)
CC2F2C F273 2CCC 228D C37C0 0398D  3131          PACK  DW(8),INPUT+22(4)   PACK MAXIMUM YEARLY OUTPUT
0C2F26 960F 2CC7      C3707        3132          OI    DW+7,X'OF'          MAKE NUMBER A LEGAL POSITIVE
0C2F2A 4FBC 20CC            037C0  3133          CVB   11,DW
CC2F2E 1BAA                        3134          SR    10,10               CLEAR REG10
0C2F3C 5CAC 2144            03844  3135          M     10,THOUSAND         MULTIPLY BY 1000
0C2F34 50BC 4CCC            0C00C  3136          ST    11,12(0,RPOINTER)
CC2F38 9101 4CC6      C0006        3137          TM    6(RPOINTER),X'01'   IS IT A PQ
CC2F3C 471C C4EE            02F76  3138          BO    PACKESTC            IF YES, GO TO PACKESTC
0C2F4C 91C3 4C05      C0005        3139          TM    5(RPOINTER),X'03'   IS IT A QUARRY
0C2F44 4780 C5C6            02F8E  3140          BZ    PACKCTM             IF NOT, GO TO PACKCTM
                                   3141 *  AT THIS POINT IT IS A QUARRY
0C2F48 912C 4C05      CCCC5        3142          TM    5(RPOINTER),X'20'   IS IT A CRUSHED STONE Q
0C2F4C 471C C4D8            02F60  3143          BO    SAMORTC             IF YES, GO TO SAMORTC
0C2F5C 9101 4C05      C0005        3144          TM    5(RPOINTER),X'01'   IS IT A PROC PLT
CC2F54 471C C4D8            02F60  3145          BO    SAMORTC             IF YES, GO TO SAMORTC
0C2F58 91C4 4C05      CC005        3146          TM    5(RPOINTER),X'04'   DOES IT USE AN INTER POINT
0C2F5C 471C C4EE            02F76  3147          BO    PACKESTC            IF YES GO TO PACKEST
CC2F6C F273 2CCC 2291 C37C0 03991  3148 SAMORTC  PACK  DW(8),INPUT+26(4)   PACK AMORTIZATION COST
CC2F66 96CF 2CC7      C37C7        3149          OI    DW+7,X'OF'
CC2F6A 4FBC 2CCC            037C0  3150          CVB   11,DW
CC2F6E 40B4 C02E            0CC2F  3151          STH   11,46(RPOINTER)     STORE AMORTIZATION COST
CC2F72 47FC C5C6            02F8E  3152          B     PACKCTM             GO TO PACKCTM
CC2F76                             3153 PACKESTC EQU   *                   (PACK ESTABLISHMENT COST)
0C2F76 F273 2CCC 2291 C37C0 03991  3154          PACK  DW(8),INPUT+26(4)   PACK ESTABLISHMENT COST
0C2F7C 96CF 2CC7      C37C7        3155          OI    DW+7,X'OF'          MAKE NUMBER A LEGAL POSITIVE
CC2F8C 4FBC 2CCC            037C0  3156          CVB   11,DW
CC2F84 1BAA                        3157          SR    10,10               CLEAR REG10
CC2F86 5CAC 2144            03844  3158          M     10,THOUSAND         MULTIPLY BY 1000
0C2F8A 50BC 4C1C            0C010  3159          ST    11,16(0,RPOINTER)
CC2F8E                             3160 PACKCTM  EQU   *
CC2F8E F273 2CCC 2295 037C0 03995  3161          PACK  DW(8),INPUT+30(4)   PACK COST TO MINE S&G OR CS
0C2F94 960F 2CC7      C37C7        3162          OI    DW+7,X'OF'
0C2F98 4FBC 2CCC            03700  3163          CVB   11,DW
0C2F9C 40BC 4C14            0C014  3164          STH   11,20(0,RPOINTER)
0C2FAC F271 2CC0 2299 C37C0 03999  3165          PACK  DW(8),INPUT+34(2)   PACK REMAINING LIFE PP (YEARS)
0C2FA6 96CF 2CC7      C37C7        3166          OI    DW+7,X'OF'
0C2FAA 4FBC 2CCC            037C0  3167          CVB   11,DW
CC2FAE 42BC 402A            0C02A  3168          STC   11,42(0,RPOINTER)
0C2FB2 F270 2CCC 229B C37C0 0399B  3169          PACK  DW(8),INPUT+36(1)   PACK IDEVFO
CC2FB8 96CF 2CC7      C37C7        3170          OI    DW+7,X'OF'          MAKE NUMBER A LEGAL POSITIVE
0C2FBC 4FBC 2CCC            037C0  3171          CVB   11,DW
CC2FCC 42BC 4C19            0C019  3172          STC   11,25(0,RPOINTER)
0C2FC4 F271 2CCC 229C 037C0 0399C  3173          PACK  DW(8),INPUT+37(2)   PACK YEAR DEVFO WILL START
CC2FCA 96CF 2CC7      C37C7        3174          OI    DW+7,X'OF'          MAKE NUMBER A LEGAL POSITIVE
CC2FCE 4FBC 2CCC            037C0  3175          CVB   11,DW
0C2FD2 42BC 4C1A            0C01A  3176          STC   11,26(0,RPOINTER)
0C2FD6 F27C 2CC0 229E C37C0 0399E  3177          PACK  DW(8),INPUT+39(1)   PACK IWIP
0C2FDC 96CF 2CC7      C37C7        3178          OI    DW+7,X'OF'          MAKE NUMBER A LEGAL POSITIVE
CC2FEC 4FBC 2CCC            037C0  3179          CVB   11,DW
0C2FE4 42BC 4C2B            0C02B  3180          STC   11,43(0,RPOINTER)
0C2FE8 F273 2C0C 229F C37C0 0399F  3181          PACK  DW(8),INPUT+40(4)   PACK PROCESSED S&G TO COMPLETION
CC2FEE 960F 2CC7      C37C7        3182          OI    DW+7,X'OF'
CC2FF2 4FBC 2CCC            03700  3183          CVB   11,DW
0C2FF6 1BAA                        3184          SR    10,10               CLEAR REG10
0C2FF8 5CAC 2144            03844  3185          M     10,THOUSAND         MULTIPLY BY 1000
0C2FFC 50BC 4C1C            0C01C  3186          ST    11,28(0,RPOINTER)
0C3CCC D2CC 23F4 22A3 C3AF4 039A3  3187          MVC   QCA(1),INPUT+44     DETERMINE QUALITY COARSE AGGREGATE
                                   3188          CALL  SETQUAL             SET QUALITY
0C3CC6 C7CC                        3189+         CNOP  0,4
0C3CC8 47FC C588            03010  3190+         B     *+8 BRANCH AROUND VCON
0C3CCC CCCCCC0C                    3191+IHB0036B DC    V(SETQUAL) ENTRY POINT ADDRESS
CC3C1C 58F0 C584            0300C  3192+         L     15,IHB0036B LOAD 15 WITH ENTRY ADR
0C3014 05EF                        3193+         BALR  14,15 BRANCH TO ENTRY POINT
CC3016 D2CC 4028 23F5 C0028 03AF5  3194          MVC   40(1,RPOINTER),QCAD MOVE QUALITY TO RPOINTER+40
CC3C1C F272 2CC0 22A4 C37C0 039A4  3195          PACK  DW(8),INPUT+45(3)   PACK PERCENT S&G TO COMPLETION
0C3C22 960F 2CC7      C3707        3196          OI    DW+7,X'OF'
0C3C26 4FBC 2CCC            037C0  3197          CVB   11,DW
0C302A 42B0 4029            0C029  3198          STC   11,41(0,RPOINTER)
0C3C2E F273 2C00 22A7 037C0 039A7  3199          PACK  DW(8),INPUT+48(4)   PACK UNPROCESSED S&G TO COMPLETION
CC3C34 960F 2CC7      C37C7        3200          OI    DW+7,X'OF'
0C3C38 4FBC 2C0C            037C0  3201          CVB   11,DW
0C3C3C 1BAA                        3202          SR    10,10               CLEAR REG10
0C303E 5CAC 2144            03844  3203          M     10,THOUSAND         MULTIPLY BY 1000
003042 95C1 402D      CC02D        3204          CLI   45(RPOINTER),X'01'   DOES DEVFO GO THRU POPULATED AREA
CC3046 4780 C5CC            03054  3205          BE    DRED                 IF YES GO TO DRED
                                   3206 *  AT THIS POINT, DEVFO GOES THRU AN AREA WHICH IS ABLE TO SUPPLY
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                     F01AUG68   5/30/69

                                   3207 *  SOME OF ITS OWN UNPROCESSED S&G
0C304A 1BAA                        3208          SR    10,10                CLEAR REGIO
0C304C 5CA0 21DC           038D0   3209          M     10,PERCFQ            DETERMINE PERCENT FROM QUARRY
CC3C50 5DAC 214C           03840   3210          D     10,HUNDRED           ''
0C3C54                             3211 DRED     EQU   *
0C3054 50BC 402C           00020   3212          ST    11,32(0,RPOINTER)
0C3C58 D2CC 23F4 22AB 03AF4 039AB  3213          MVC   QCA(1),INPUT+52     DETERMINE QUALITY COARSE AGGREGATE
                                   3214          CALL  SETQUAL             SET QUALITY
0C3C5E 07CC                        3215+         CNOP  0,4
0C3C6C 47FC C5EC           03068   3216+         B     *+8 BRANCH AROUND VCON
0C3C64 CCCCCCCC                    3217+IHB0037B DC    V(SETQUAL) ENTRY POINT ADDRESS
0C3C68 58FC C5DC           03064   3218+         L     15,IHB0037B LOAD 15 WITH ENTRY ADR
0C306C 05EF                        3219+         BALR  14,15 BRANCH TO ENTRY POINT
0C306F D2CC 402C 23F5 C002C 03AF5  3220          MVC   44(1,RPOINTER),QCAD MOVE QUALITY T6-9POINTER+44
CC3C74 F273 2CCC 22AC C3700 039AC  3221          PACK  DW(8),INPUT+53(4)   PACK CRUSHED STONE TO COMPLETION
0C307A 960F 2C07      C3707        3222          OI    DW+7,X'0F'
0C3C7E 4FBC 2CCC           03700   3223          CVB   11,DW
0C3C82 1BAA                        3224          SR    10,10                CLEAR REG10
0C3C84 5CAC 2144           03844   3225          M     10,THOUSAND          MULTIPLY BY 1000
0C3C88 5080 4024           00024   3226          ST    11,36(0,RPOINTER)
0C3C8C D2CC 23F4 22BC C3AF4 039BC  3227          MVC   QCA(1),INPUT+57     DETERMINE QUALITY COARSE AGGREGATE
                                   3228          CALL  SETQUAL             SET QUALITY
CC3092 C7CC                        3229+         CNOP  0,4
CC3C94 47FC C614           03C9C   3230+         B     *+8 BRANCH AROUND VCON
0C3C98 CCCCCCCC                    3231+IHB0038B DC    V(SETQUAL) ENTRY POINT ADDRESS
0C309C 58FC C61C           03098   3232+         L     15,IHB0038B LOAD 15 WITH ENTRY ADR
0C3CAC C5EF                        3233+         BALR  14,15 BRANCH TO ENTRY POINT
CC3CA2 D2CC 4C3C 23F5 CC030 03AF5  3234          MVC   48(1,RPOINTER),QCAD MOVE QUALITY TO RPOINTER+48
0C3CA8 F271 2CCC 22B1 C37C0 039B1  3235          PACK  DW(8),INPUT+58(2)   PACK YEARS TO COMPLETION
0C3CAE 960F 2CC7      C37C7        3236          OI    DW+7,X'0F'
0C3CB2 4FBC 2CCC           037C0   3237          CVB   11,DW
0C3CB6 42BC 401B           0001B   3238          STC   11,27(0,RPOINTER)
0C3CBA 92CC 4031      C0031        3239          MVI   49(RPOINTER),X'00'  SET OUTSIDE Q INDICATOR = 0
0C3CBE F272 2CCC 22B4 C37C0 039B4  3240          PACK  DW(8),INPUT+61(3)   PACK ROW QUARRY NO 1
0C3CC4 960F 2CC7      C37C7        3241          OI    DW+7,X'0F'          MAKE NUMBER A LEGAL POSITIVE
0C3CC8 4FBC 2CCC           037C0   3242          CVB   11,DW
0C3CCC 40BC 404C           0C040   3243          STH   11,64(0,RPOINTER)
0C3CDC F272 2CCC 22B7 C3700 039B7  3244          PACK  DW(8),INPUT+64(3)   PACK COL QUARRY NO 1
CC3CD6 960F 2C07      03707        3245          OI    DW+7,X'0F'          MAKE NUMBER A LEGAL POSITIVE
0C3CDA 4FBC 2CCC           037C0   3246          CVB   11,DW
0C3CDE 40BC 4042           0C042   3247          STH   11,66(0,RPOINTER)
0C3CE2 F272 2CCC 22BA C37C0 039BA  3248          PACK  DW(8),INPUT+67(3)   PACK ROW QUARRY NO 2
0C3CE8 960F 2CC7      C3707        3249          OI    DW+7,X'0F'
0C3CEC 4FBC 2CCC           037C0   3250          CVB   11,DW
CC3CFC 40BC 4C44           00C44   3251          STH   11,68(0,RPOINTER)
0C3CF4 F272 2CCC 22BD C37C0 039BD  3252          PACK  DW(8),INPUT+70(3)   PACK COL QUARRY NO 2
0C3CFA 960F 2CC7      C37C7        3253          OI    DW+7,X'0F'
0C3CFE 4FBC 2CCC           037C0   3254          CVB   11,DW
0C31C2 40BC 4C46           0C046   3255          STH   11,70(0,RPOINTER)
CC31C6 F272 2C0C 22CC C37C0 039C0  3256          PACK  DW(8),INPUT+73(3)   PACK ROW QUARRY NO 3
0C31CC 960F 2CC7      C37C7        3257          OI    DW+7,X'0F'
0C311C 4FBC 2CC0           037C0   3258          CVB   11,DW
0C3114 4CBC 4C48           0C048   3259          STH   11,72(0,RPOINTER)
0C3118 F272 2CCC 22C3 C37C0 039C3  3260          PACK  DW(8),INPUT+76(3)   PACK COL QUARRY NO 3
0C311E 960F 2CC7      C3707        3261          OI    DW+7,X'0F'
CC3122 4FBC 2CCC           037C0   3262          CVB   11,DW
0C3126 40B0 404A           0C04A   3263          STH   11,74(0,RPOINTER)
0C312A D203 4C5C 2C6C CC050 0376C  3264          MVC   80(4,RPOINTER),MINONE  SET IP ADDR = -1
0C313C                             3265 CHKQ     EQU   *
0C313C 91C3 4CC5      CCC05        3266          TM    5(RPOINTER),X'03'   TEST TO SEE IF IT IS A QUARRY
0C3134 475C C6BA           03142   3267          BC    5,ADDQ              IF YES (IE 1,2,3) GO TO ADD QUARRY
                                   3268 *  AT THIS POINT IT WAS NOT A QUARRY
0C3138 D203 4C34 2C6C CC034 03760  3269          MVC   52(4,RPOINTER),MINONE MAKE Q ADDR -1
CC313E 47FC C6C8           03150   3270          B     TFPQ                GO TO TEST FOR PQ
                                   3271 *  AT THIS POINT IT WAS A QUARRY
CC3142 504C 2C84           03784   3272 ADDQ     ST    RPOINTER,AQTBA      STORE ADDR OF Q TO BE ADDED IN AQTBA
0C3146 58FC 2C14           03714   3273          L     15,ASRAQ
0C314A C5EF                        3274          BALR  14,15               CALL SUBROUTINE ADD QUARRY
0C314C 47FC C6E4           0316C   3275          B     TFDEVFO             GO TO TEST FOR DEVFO
0C315C 9101 4CC6      CCC06        3276 TFPQ     TM    6(RPOINTER),X'01'   IS IT A PQ
0C3154 471C C6DA           03162   3277          BO    ADDPQ               IF SO, GO TO ADD PQ
                                   3278 *  AT THIS POINT IT WAS NOT A PQ
0C3158 D2C3 4C34 2C6C CC034 03760  3279          MVC   52(4,RPOINTER),MINONE  MAKE PQ ADDR PTR = -1
0C315E 47FC C6E4           0316C   3280          B     TFDEVFO             GO TO TEST FOR DEVFO
                                   3281 *  AT THIS POINT IT WAS A PQ
0C3162 504C 2C88           03788   3282 ADDPQ    ST    RPOINTER,APQTBA     STORE ADDRESS OF PQ TO BE ADDED
0C3166 58FC 2C18           03718   3283          L     15,ASRAPQ
0C316A C5EF                        3284          BALR  14,15               CALL SUBROUTINE ADD PQ
0C316C 9101 4019      C0019        3285 TFDEVFO  TM    25(RPOINTER),1      IS IT A DEVELOPMENT FORECASTED
0C317C 471C C6F6           0317E   3286          BO    ADDDEVFO            IF SO, GO TO ADD A DEVELOPMENT FOR
                                   3287 *  AT THIS POINT IT WAS NOT A DEVFO
0C3174 D2C3 4038 2C6C CC038 03760  3288          MVC   56(4,RPOINTER),MINONE MAKE DEVFO ADDR PTR -1
0C317A 47F0 C7CC           03188   3289          B     TFWIP               GO TO TEST FOR WIP
                                   3290 *  AT THIS POINT IT WAS A DEVFO
0C317E 5040 2C8C           0378C   3291 ADDDEVFO ST    RPOINTER,ADEVTBA    STORE ADDR OF DEVFO TO BE ADDED
0C3182 58FC 2C1C           0371C   3292          L     15,ASRADEV
0C3186 05EF                        3293          BALR  14,15               CALL SUBR ADD DEVFO
0C3188 91C1 4028      C002B        3294 TFWIP    TM    43(RPOINTER),1      IS IT A WORK IN PROCESS
0C318C 4710 C712           0319A   3295          BO    ADDWIP              IF SO GO TO ADD WORK IN PROCESS
                                   3296 *  AT THIS POINT IT WAS NOT A WIP
0C319C D203 403C 2C60 CC03C 03760  3297          MVC   60(4,RPOINTER),MINONE MAKE WIP ADDR PTR -1
0C3196 47F0 C71C           031A4   3298          B     ADVPTR              GO TO ADVANCE POINTER
                                   3299 *  AT THIS POINT IT WAS A WIP
0C319A 5C40 2C9C           03790   3300 ADDWIP   ST    RPOINTER,AWIPTBA    STORE ADDRESS OF WIP TO BE ADDED
0C319E 58FC 2C2C           03720   3301          L 15,ASRAWIP
CC31A2 05EF                        3302          BALR  14,15               CALL SUBR ADD WIP
0C31A4 414C 4C54           00054   3303 ADVPTR   LA    RPOINTER,84(0,RPOINTER) ADD 84 TO RPOINTER
C031A8 47FC C320           02DA8   3304          B     READCARD            GO TO READCARD UNTIL ALL CARDS READ
0C31AC                             3305 ALLCDSRO EQU   *
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                              F01AUG68  5/30/69

0031AC 9500 C9A2      0342A       3306          CLI   ERRORS,X'00'         WERE THERE ANY ERRORS
0031B0 4780 C75C            031E4 3307          BE    TWNE                 IF NOT, GO TO TWNE
                                  3308          CLOSE (INDCB,,OUTDCB)
0031B4                            3309+         CNOP  0,4
0031B4 4510 C738            031C0 3310+         BAL   1,*+12 BRANCH AROUND LIST
0031B8 00                         3311+         DC    AL1(0) OPTION BYTE
0031B9 0008C4                     3312+         DC    AL3(INDCB) DCB ADDRESS
0031BC 80                         3313+         DC    AL1(128) OPTION BYTE
0031BD 0009A4                     3314+         DC    AL3(OUTDCB) DCB ADDRESS
0031C0 0A14                       3315+         SVC   20 ISSUE CLOSE SVC
                                  3316          REEXIT
0031C2 1810                       3317+         LR    1,13
0031C4 58D0 D004            00004 3318+         L     13,4(,13)
0031C8                            3319+         CNOP  0,4
0031C8 47F0 C748            031D0 3320+         B     *+8 BRANCH AROUND SP+LV
0031CC 00                         3321+         DC    AL1(0) SUBPOOL VALUE
0031CD 000048                     3322+         DC    AL3(72) LENGTH
0031D0 5800 C744            031CC 3323+         L     0,*-4 LOAD SP AND LV
0031D4 0A0A                       3324+         SVC   10 ISSUE FREEMAIN SVC
0031D6 98EC D00C            0000C 3325+         LM    14,12,12(13) RESTORE THE REGISTERS
0031DA 92FF D00C      0000C       3326+         MVI   12(13),X'FF' SET RETURN INDICATION
0031DE 41F0 0000            00000 3327+         LA    15,0(0,0) LOAD RETURN CODE
0031E2 07FE                       3328+         BR    14 RETURN
0031E4 9211 22C8      039C8       3329 TWNE     MVI   CARCONT,X'11'        WRITE MESSAGE
0031E8 D226 22DD C9A9 039DD 03431 3330          MVC   OUTLINE+20(L'ICOK),ICOK   WRITE NO ERRORS
0031EE 58F0 204C            0374C 3331          L     15,ALINEOUT
0031F2 05EF                       3332          BALR  14,15
                                  3333 *  THIS SECTION SETS THE SELF-PRESERVATION BIT TO 1 FOR ALL THOSE
                                  3334 *  QUARRIES WHOSE OPERATORS OWN AT LEAST ONE MORE POTENTIAL QUARRY
0031F4 5890 2064            03764 3335          L     9,SQCH               LOAD REG9 WITH START Q CHAIN
0031F8 1299                       3336 SPQLOOP  LTR   9,9                  ARE WE DONE WITH ALL QUARRIES
0031FA 4740 C7AA            03232 3337          BM    DONESPC              IF SO, GO TO DONESPC
0031FE 5880 2068            03768 3338          L     8,SPQCH              LOAD REG8 WITH START PQ CHAIN
003202 1288                       3339 SPLOOP   LTR   8,8                  ARE WE DONE WITH ALL PQ'S
003204 4740 C79E            03226 3340          BM    DNWTSP               IF YES, GO TO DNWTSP
003208 D500 9007 8007 00007 00007 3341          CLC   7(1,9),7(8)          IS PQ(8) OWNED BY SAME OWNER Q(9)
00320E 4780 C792            0321A 3342          BE    HWTSP                IF SAME OWNER GO TO HWTSP
003212 5880 8034            00034 3343          L     8,52(0,8)            LOAD ADDR NEXT PQ INTO REG8
003216 47F0 C77A            03202 3344          B     SPLOOP               GO TO SPLOOP
00321A                            3345 HWTSP    EQU   *                    (HE WISHES TO SELF PRESERVE)
00321A 9608 9005      00005       3346          OI    5(9),X'08'           SET SELF PRESERVE BIT = 1
00321E 5890 9034            00034 3347          L     9,52(0,9)            LOAD REG9 WITH ADDR NEXT QUARRY
003222 47F0 C770            031F8 3348          B     SPQLOOP              GO TO SPQLOOP
003226                            3349 DNWTSP   EQU   *                    (DOES NOT WISH TO SELF PRESERVE)
003226 94F7 9005      00005       3350          NI    5(9),B'11110111'     SET SELF PRESERVE BIT = 0
00322A 5890 9034            00034 3351          L     9,52(0,9)            LOAD ADDR NEXT Q INTO REG9
00322E 47F0 C770            031F8 3352          B     SPQLOOP              GO TO SPQLOOP
003232                            3353 DONESPC  EQU   *                    (DONE SELF PRESERVATION CHECK)
003232 D203 4000 206C 00000 0376C 3354          MVC   0(4,RPOINTER),MINONE  SET ROW & COL = -1 ---END OF CATA
                                  3355 *
                                  3356 *  THIS PORTION ASSIGNS QUARRY ADDRESSES TO DEVFO'S AND WIP'S
                                  3357 *
003238 58B0 206C            0376C 3358          L     11,SDEVFOCH          LOAD 11 WITH START DEVFO CHAIN
00323C 12BB                       3359          LTR   11,11                ARE THERE ANY DEVFO'S
00323E 4740 C964            033EC 3360          BM    TWIPS                IF NOT GO TO TEST WIP'S
003242 1B88                       3361          SR    8,8                  CLEAR REG 8
003244 4180 8001            00001 3362          LA    8,1(0,8)             MAKE REG 8 CONTAIN 1
003248 5890 2064            03764 3363 CONTD    L     9,SQCH               LOAD REG9 WITH START QUARRY CHAIN
00324C D501 B040 CA1A 00040 034A2 3364          CLC   64(2,11),=H'999'     IS Q1 AN OUTSIDE Q
003252 4770 C7F6            0327E 3365          BNE   NOTOUT1              IF NOT GO TO NOTOUT1
003256 9601 B031      00031       3366          OI    49(11),X'01'         SET OUTSIDE Q INDICATOR = 00000001
00325A 5850 20CC            037CC 3367          L     5,AOSQ               LOAD REG5 WITH ADDR OUTSIDE Q
00325E 1255                       3368 OUTDONE1 LTR   5,5                  ARE WE DONE
003260 4740 C97E            03406 3369          BM    INCARERR             IF SO, THERE IS AN ERROR GOTO INCARE
003264 D501 5000 B042 00000 00042 3370          CLC   0(2,5),66(11)        IS Q(5) THE CORRECT Q
00326A 4770 C7EE            03276 3371          BNE   LANOQ1               IF NOT, GO TO LANOQ1
00326E 5050 B040            00040 3372          ST    5,64(0,11)           STORE ADDR OF OUTSIDE Q
003272 47F0 C87E            03306 3373          B     IQ2SPEC              GO TO IS Q2 SPECIFIED
003276 4150 5010            00010 3374 LANOQ1   LA    5,16(0,5)            LOAD REG5 WITH ADDR NEXT OUTSIDE Q
00327A 47F0 C7D6            0325E 3375          B     OUTDONE1             GO TO OUTDONE1
00327E 5850 B040            00040 3376 NOTOUT1  L     5,64(0,11)           LOAD Q1 ADDR INTO REG5
003282 1255                       3377          LTR   5,5                  IS ADDR 0 (IS Q1 SPECIFIED)
003284 4780 C878            03300 3378          BZ    Q1NSPEC              IF 0 GO TO Q1 NOT SPECIFIED
                                  3379 *  AT THIS POINT Q1 IS SPECIFIED
003288 D503 B040 9000 00040 00000 3380 Q1TEST   CLC   64(4,11),0(9)        IS Q(9) THE SAME Q AS Q1
00328E 4770 C86E            032F6 3381          BNE   UPREG91              IF NOT GO TO UPREG91
                                  3382 *  AT THIS POINT REG9 CONTAINS THE ADDR OF Q1
003292 9140 9005      00005       3383          TM    5(9),X'40'           IS Q(9) A S&G QUARRY
003296 4780 C878            03300 3384          BZ    Q1NSPEC              IF NOT, GO TO Q1 NOT SPECIFIED
                                  3385 *  THIS SECTION FINDS THE QUARRY WHICH WILL SUPPLY THE Q WHICH IS AN
                                  3386 *  INTERMEDIATE POINT
00329A 9110 9005      00005       3387          TM    5(9),X'10'           IS Q(9) USED AS AN INTER PT
00329E 4780 C866            032EE 3388          BZ    Q1OK                 IF NOT GO TO Q1OK
                                  3389 *  AT THIS POINT Q(9) IS AN INTERMEDIATE POINT
0032A2 5090 B050            00050 3390          ST    9,80(0,11)           STORE ITS ADDR IN IP LOCATION
0032A6 58A0 2064            03764 3391          L     10,SQCH              LOAD REG10 WITH START Q CHAIN
0032AA 12AA                       3392 LFNQUIP  LTR   10,10                ARE WE DONE LOOKING FOR AN Q
0032AC 4740 C85A            032E2 3393          BM    NCQDONE              IF YES, GO TO NCQDONE
0032B0 D500 A007 9007 00007 00007 3394          CLC   7(1,10),7(9)         IS Q(10) OWNED BY SAME OWNER AS Q(9)
0032B6 4770 C84E            032D6 3395          BNE   NCQ                  IF NOT GO TO NCQ
0032BA 9544 A005      00005       3396          CLI   5(10),X'44'          IS Q(10) A S&G Q WHICH USES AN IP
0032BE 47E0 C84E            032D6 3397          BNO   NCQ                  IF NOT, GO TO NCQ
0032C2 4360 B028            00028 3398          IC    6,40(11)             INSERT QUALITY S&G REQ'D
0032C6 4460 C856            032DE 3399          EX    6,IQAQOK             IS Q(10) QUALITY OK
0032CA 47E0 C84E            032D6 3400          BNO   NCQ                  IF NOT, GO TO NCQ
                                  3401 *  AT THIS POINT, REG10 CONTAINS A Q OWNED BY SAME OWNER AS Q(9) AND
                                  3402 *  IT USES AN INTERMEDIATE POINT
0032CE 50A0 B040            00040 3403          ST    10,64(0,11)          STORE ITS ADDR IN Q1
0032D2 47F0 C87E            03306 3404          B     IQ2SPEC              GO TO IQ2SPEC
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                              F01AUG68   5/30/69

0032D6 58A0 A034             00034  3405 NCQ      L      10,52(0,10)          LOAD REG10 WITH ADDR NEXT Q IN CHAIN
0C32CA 47F0 C822             032AA  3406          B      LFNQUIP              GO TO LFNQUIP
0C32DE 91CC AC17       C0017        3407 IQAQOK   TM     23(10),X'00'         IS QUALITY O.K.
0032E2 50A0 B04C             00040  3408 NCQDONE  ST     10,64(0,11)          SET Q1 ADDR = -1
0C32E6 50A0 BC50             00050  3409          ST 10,80(0,11)              SET INTERMEDIATE PT ADDR = -1
0032EA 47F0 C87E             033C6  3410          B      IQ2SPEC              GO TO IQ2SPEC
0C32EE 509C B040             00040  3411 Q1OK     ST     9,64(0,11)           STORE ADDR (IN REG9) OF Q1
0C32F2 47FC C87E             03306  3412          B      IQ2SPEC              GO TO IS Q2 SPECIFIED
0C32F6 589C 9034             00034  3413 UPREG91  L      9,52(0,9)            LOAD REG9 WITH ADDR NEXT Q IN CHAIN
0C32FA 1299                         3414          LTR    9,9                  IS ADDR NEG (ARE WE DONE)
0C32FC 47BC C8CC             03288  3415          BNM    Q1TEST               IF NOT GO TO Q1TEST
0033C0 D203 B040 2C6C C0040 03760  3416 Q1NSPEC  MVC    64(4,11),MINONE      SET Q1 ADDR = -1
0C33C6 589C 2C64             03764  3417 IQ2SPEC  L      9,SQCH               LOAD REG9 WITH START QUARRY CHAIN
0C33CA D501 B044 CA1A CC044 034A2  3418          CLC    68(2,11),=H'999'     IS Q2 AN OUTSIDE Q
0C331C 477C C8B4             0333C  3419          BNE    NOTOUT2              IF NOT GO TO NOTOUT2
0C3314 9602 BC31       C0031        3420          OI     49(11),X'02'         SET OUTSIDE Q INDICATOR = 00000010
003318 585C 2C0C             0370C  3421          L      5,AOSQ               LOAD REG5 WITH ADDR OUTSIDE Q
0C331C 1255                         3422 OUTDONE2 LTR    5,5                  ARE WE DONE
0C331E 4740 C97E             03406  3423          BM     INCARERR             IF SO, THERE IS AN ERROR GOTO INCARE
CC3322 D501 5CCC BC46 CCCC0 00046  3424          CLC    0(2,5),70(11)        IS Q(5) THE CORRECT Q
0C3328 477C C8AC             03334  3425          BNE    LANOQ2               IF NOT, GO TO LANOQ2
0C332C 505C BC44             0C044  3426          ST     5,68(0,11)           STORE ADDR OF OUTSIDE Q
0C333C 47FC C8E8             03370  3427          B      IQ3SPEC              GO TO IS Q3 SPECIFIED
0C3334 415C 5C1C             00010  3428 LANOQ2   LA     5,16(0,5)            LOAD REG5 WITH ADDR NEXT OUTSIDE Q
0C3338 47FC C894             0331C  3429          B      OUTDONE2             GO TO OUTDONE2
0C333C                              3430 NOTOUT2  EQU    *
0C333C 585C B044             00044  3431          L      5,68(0,11)           LOAD REG5 WITH ADDR Q2
0C334C 1255                         3432          LTR    5,5                  IS Q2 SPECIFIED
0C3342 4780 C8E2             0336A  3433          BZ     Q2NSPEC              IF 0, GO TO Q2 NOT SPECIFIED
                                    3434 *  AT THIS POINT, Q2 IS SPECIFIED
0C3346 D5C3 B044 9CCC C0044 0C000  3435 Q2TEST   CLC    68(4,11),0(9)        DOES REG9 CONTAIN ADDR OF Q2
0C334C 477C C8D8             03360  3436          BNE    UPREG92              IF NOT GO TO UPREG92
                                    3437 *  AT THIS POINT, REG9 CONTAINS THE ADDR OF Q2
00335C 914C 9CC5       CC0C5        3438          TM     5(9),X'40'           IS Q(9) A S&G QUARRY
0C3354 478C C8E2             0336A  3439          BZ     Q2NSPEC              IF NOT, GO TO Q2 NOT SPECIFIED
C03358 509C BC44             0C044  3440          ST     9,68(0,11)           STORE ADDR (IN REG9) OF Q2
CC335C 47FC C8E8             03370  3441          B      IQ3SPEC              GO TO IS Q3 SPECIFIED
0C336C 589C 9C34             00034  3442 UPREG92  L      9,52(0,9)            LOAD REG9 WITH ADDR NEXT Q IN CHAIN
0C3364 1299                         3443          LTR    9,9                  IS ADDR NEG (ARE WE DONE)
0C3366 478C C8BE             03346  3444          BNM    Q2TEST               IF NOT, GO TO Q2TEST
0C336A D2C3 BC44 2C6C CC044 03760  3445 Q2NSPEC  MVC    68(4,11),MINONE      SET Q2 ADDR = -1
0C337C 589C 2C64             03764  3446 IQ3SPEC  L      9,SQCH               LOAD REG9 WITH START QUARRY CHAIN
0C3374 D5C1 BC48 CA1A CC048 034A2  3447          CLC    72(2,11),=H'999'     IS Q3 AN OUTSIDE Q
0C337A 4770 C91E             033A6  3448          BNE    NOTOUT3              IF NOT GO TO NOTOUT3
0C337E 9604 8C31       C0031        3449          OI     49(11),X'04'         SET OUTSIDE Q INDICATOR = 00000100
0C3382 5850 2CCC             0370C  3450          L      5,AOSQ               LOAD REG5 WITH ADDR OUTSIDE Q
CC3386 1255                         3451 OUTDONE3 LTR    5,5                  ARE WE DONE
0C338P 474C C97E             03406  3452          BM     INCARERR             IF SO, THERE IS AN ERROR GOTO INCARE
0C338C D501 5CC0 B04A CCCC0 0004A  3453          CLC    0(2,5),74(11)        IS Q(5) THE CORRECT Q
CC3392 477C C916             0339E  3454          BNE    LANOQ3               IF NOT, GO TO LANOQ3
003396 505C BC48             0C048  3455          ST     5,72(0,11)           STORE ADDR OF OUTSIDE Q
0C339A 47FC C952             033DA  3456          B      CHAINCK              GO TO CHAIN CHECK
CC339E 4150 5C1C             00010  3457 LANOQ3   LA     5,16(0,5)            LOAD REG5 WITH ADDR NEXT OUTSIDE Q
CC33A2 47FC C8FE             03386  3458          B      OUTDONE3             GO TO OUTDONE3
0C33A6                              3459 NOTOUT3  EQU    *
0C33A6 585C B048             0C048  3460          L      5,72(0,11)           LOAD ADDR Q3 INTO REG5
0C33AA 1255                         3461          LTR    5,5                  IS ADDR 0 (IS Q3 SPECIFIED)
0C33AC 478C C94C             033D4  3462          BZ     Q3NSPEC              IF 0 GO TO Q3 NOT SPECIFIED
CC33BC C503 B048 9CCC CC048 0C0C0  3463 Q3TEST   CLC    72(4,11),0(9)        DOES REG9 CONTAIN ADDR OF Q3
CC33B6 4770 C942             033CA  3464          BNE    UPREG93              IF NOT GO TO UPREG93
CC33BA 912C 9C05       CC005        3465          TM     5(9),X'20'           IS Q(9) A CRUSHED STONE QUARRY
0033BE 4780 C94C             033D4  3466          BZ     Q3NSPEC              IF NOT GO TO Q3 NOT SPECIFIED
0C33C2 5090 8C48             0C048  3467          ST     9,72(0,11)           STORE ADDR (IN REG9) OF Q3
0033C6 47FC C952             033DA  3468          B      CHAINCK              GO TO CHAINCK
0C33CA 589C 9C34             00034  3469 UPREG93  L      9,52(0,9)            LOAD REG9 WITH ADDR NEXT Q IN CHAIN
0C33CE 1299                         3470          LTR    9,9                  IS ADDR NEG (ARE WE DONE)
0C33CC 47BC C928             03380  3471          BNM    Q3TEST               IF NOT, GO TO Q3TEST
0C33D4 D203 8C48 2C6C CC048 03760  3472 Q3NSPEC  MVC    72(4,11),MINONE      SET Q3 ADDR = -1
0C33CA 598C CA14             0349C  3473 CHAINCK  C      8,=F'1'              DOES REG8 CONTAIN 1 (ARE WE IN DEVFO
                                    3474 *                                     CHAIN)
0C33CE 4770 C976             033FE  3475          BNE    IWIPCH               IF NOT GO TO IN WIP CHAIN
                                    3476 *  AT THIS POINT WE ARE IN THE DEVFO CHAIN
0C33E2 58BC BC38             0C038  3477          L      11,56(0,11)          LOAD REG11 WITH NEXT DEVFO IN CHAIN
CC33E6 12BB                         3478          LTR    11,11                ARE WE DONE WITH DEVFO'S
0C33E8 47BC C7CC             03248  3479          BNM    CONTD                IF NOT DONE GO TO CONTD
                                    3480 *  AT THIS POINT WE ARE DONE WITH DEVFO CHAIN
0C33EC 1888                         3481 TWIPS    SR     8,8                  CLEAR REG8
0C33EE 58BC 2C7C             03770  3482          L      11,SWIPCH            LOAD REG11 WITH START WIP CHAIN
0C33F2 12BB                         3483 TWIPLP   LTR    11,11                IS ADDR NEG (ARE WE DONE WITH WIP
                                    3484 *                                     CHAIN)
0C33F4 47BC C7CC             03248  3485          BNM    CONTD                IF NOT GO TO CONTD
0C33F8 58FC 2C5C             03750  3486          L      15,ABEGINIT          LOAD REG15 WITH ADDR BEGINIT
0C33FC C7FF                         3487          BR     15                   AND BRANCH TO BEGINIT
0C33FE 58BC BC3C             0C03C  3488 IWIPCH   L      11,60(0,11)          LOAD REG11 WITH NEXT WIP IN CHAIN
0C34C2 47FC C96A             033F2  3489          B      TWIPLP               GO TO TWIPLP
0C34C6                              3490 INCARERR EQU    *
0C34C6 92C1 C9A2       C342A        3491          MVI    ERRORS,X'01'          SET ERRORS = 1
0C34CA 9211 22C8       C39C8        3492          MVI    CARCONT,X'11'         WRITE & SKIP 1
0C34CE D212 22CD C9F8 C39CD 03480  3493          MVC   OUTLINE+20(L'RCINE),RCINE
0C3414 D202 22E1 C9A3 C39E1 0342B  3494          MVC   OUTLINE+24(3),TEMPR
0C341A D202 22ED C9A6 C39ED 0342E  3495          MVC   OUTLINE+36(3),TEMPC
0C342C 58FC 204C             0374C  3496          L      15,ALINEOUT
0C3424 C5EF                         3497          BALR   14,15
0C3426 47FC C71C             031A4  3498          B      ADVPTR                GO TO ADVPTR
CC342A                              3499 ERRORS   DS     X
0C342B                              3500 TEMPR    DS     CL3
0C342E                              3501 TEMPC    DS     CL3
003431 C9D5D7E4E34CC3C1             3502 ICOK     DC     C'INPUT CARDS CONTAINED NO OBVIOUS ERRORS'
0C3458 E3C8C54CC6D6D3D3             3503 INMES    DC     C'THE FOLLOWING INPUT CARDS CONTAIN ERRORS'
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                              F01AUG68   5/30/69

0C3480 D9D6E64040404068              3504 RCINE    DC    C'ROW     , COLUMN    '
                                     3505 *  WE ARE NOW READY TO BEGIN ACTUAL SIMULATION
                                     3506 *     ALL REGISTERS EXCEPT -- 13 = MSAVEAREA ADDRESS
                                     3507 *                            12 = BASE REGISTER
                                     3508 *                             2 = ADDRESS OF COMMON AREA  MAY BE USED
                                     3509 *
                                     3510 *                   TABLE ARRANGEMENT (STARTING AT MATRIX)
                                     3511 *                   ------------------------------------
                                     3512 *  REL ADDR    LENGTH                DESCRIPTION
                                     3513 *  --------    ------                -----------
                                     3514 *
                                     3515 *    +0          2                  ROW
                                     3516 *    +2          2                  COL
                                     3517 *    +4          1                  ZONING LAW
                                     3518 *    +5          1                  IS IT A QUARRY
                                     3519 *    +6          1                  IS IT A POTENTIAL QUARRY
                                     3520 *    +7          1                  OWNER
                                     3521 *    +8          4                  LIFE OF QUARRY
                                     3522 *   +12          4                  MAXIMUM YEARLY OUTPUT
                                     3523 *   +16          4                  ESTABLISHMENT COST
                                     3524 *   +20          2                  COST TO QUARRY S&G OR CRUSHED STONE
                                     3525 *   +22          1                  QUALITY, FINE AGGREGATE
                                     3526 *   +23          1                  QUALITY, COARSE AGGREGATE
                                     3527 *   +24          1                  PERCENT SAND (IF SAND&GRAVEL)
                                     3528 *   +25          1                  IS A DEVELOPMENT FORECASTED
                                     3529 *   +26          1                  YEAR DEVFO WILL START
                                     3530 *   +27          1                  YEARS TO COMPLETION
                                     3531 *   +28          4                  PROCESSED S&G TO COMPLETION
                                     3532 *   +32          4                  UNPROCESSED S&G TO COMPLETION
                                     3533 *   +36          4                  CRUSHED STONE TO COMPLETION
                                     3534 *   +40          1                  MINIMUM QUALITY PROCESSED S&G REQ'D
                                     3535 *   +41          1                  PERCENT SAND TO COMPLETION
                                     3536 *   +42          1                  REMAINING LIFE PROCESSING PLANT
                                     3537 *   +43          1                  IS WORK IN PROCESS
                                     3538 *   +44          1                  MINIMUM QUALITY UNPROCESSED S&G REQD
                                     3539 *   +45          1                  IS GRID OCCUPIED
                                     3540 *   +46          2                  AMORTIZATION COST
                                     3541 *   +48          1                  MINIMUM QUALITY CS REQUIRED
                                     3542 *   +49          1                  IS OUTSIDE QUARRY SPECIFIED
                                     3543 *                                  0 = NO,  00000001 = PROCESSED S&G
                                     3544 *                                  00000010 = UNPROCESSED S&G,
                                     3545 *                                  00000100 = CRUSHED STONE
                                     3546 *   +50          I
                                     3547 *   +51
                                     3548 *   +52          4                  Q OR PQ POINTER
                                     3549 *   +56          4                  DEVFO POINTER
                                     3550 *   +60          4                  WIP POINTER
                                     3551 *   +64          4                  ADDRESS Q NO 1
                                     3552 *   +68          4                  ADDRESS QUARRY NO 2
                                     3553 *   +72          4                  ADDRESS QUARRY NO 3
                                     3554 *   +76          4                  USAGE DURING PRESENT PERIOD
                                     3555 *   +80          4                  INTERMEDIATE POINT ADDRESS
                                     3556 *
0C3498                               3557          LTORG ,
0C3498 42640CCC                      3558                =E'100'
0C349C CCCCCC01                      3559                =F'1'
0C34AC CC8C                          3560                =H'128'
0C34A2 C3E7                          3561                =H'999'
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                                   F01AUG68   5/30/69

                                   3563 *  THIS SUBROUTINE PICKS THE LOWEST COST POTENTIAL QUARRIES FOR
                                   3564 *  1) THOSE WHICH MUST HAVE A PROCESSING PLANT BUILT AT THE SITE,
                                   3565 *  2) THOSE WHICH USE THE ZONED OUT OR DEPLETED QUARRY AS AN INTER PT,
                                   3566 *  AND 3) THOSE WHICH DO NOT REQUIRE PROCESSING
                                   3567 *  INPUT PARAMETERS ARE QIQ = QUARRY IN QUESTION (ZONED OUT OR DEPLETED
                                   3568 *      AND STRATEGY   = 0 --TEST FOR UNPROCESSED ONLY TO WGCUPSG
                                   3569 *                     = 1 -- TEST FOR PROC PLT AT NEW Q - TO WGCPSG
                                   3570 *                     = 2 -- TEST WITH INTERMEDIATE POINT
                                   3571 *                       = 3 -- TEST WITH ALL OF THE ABOVE
                                   3572 *                     = 4 -- TEST UNPROCESSED ONLY - TO Q(4)
                                   3573 *                     = 5 -- TEST FOR PROC PLT AT NEW Q - TO Q(4)
                                   3574 *                     = 6 -- SAME AS 2
                                   3575 *                     = 7 -- NOS. 4,5,6
                                   3576 *  OUTPUT PARAMETERS ARE ADDRPQ1 = ADDRESS LOWEST COST PQ WITH PP
                                   3577 *                        COSTCMP1 = TOTAL COST OF ''
                                   3578 *                        AMORT1 = AMORTIZATION COST OF ''
                                   3579 *                        ADDRPQ2 = ADDRESS OF LOWEST COST PQ USING IP
                                   3580 *                        COSTCMP2 = TOTAL COST USING ''
                                   3581 *                        AMORT2 = AMORTIZATION COST USING Q(4) +PQ(9)
                                   3582 *                        ADDRPQ3 = ADDRESS OF LOWEST COST NON PROC PQ
                                   3583 *                        COSTCMP3 = TOTAL COST OF ''
                                   3584 *                        AMORT3 = AMORTIZATION COST OF ''
003484                             3585          USING *,3
0034A4                             3586 SRPQCOST EQU   *                     (SUBROUTINE POTENTIAL QUARRY COST)
0034A4 90EC D00C            0000C  3587          STM   14,12,12(13)
0034A8 183F                        3588          LR    3,15
0034AA 58E0 3200            036A4  3589          L     14,ASAVPQC
0034AE 50ED 0008            00008  3590          ST    14,8(13)
0034B2 50DE 0004            00004  3591          ST    13,4(14)
0034B6 18DE                        3592          LR    13,14
0034B8 D203 2104 213C 03804 0383C  3593          MVC   COSTCMP1(4),LARPOSN  SET COSTCMP1 = LARGEST + NUMBER
0034BE D203 2108 213C 03808 0383C  3594          MVC   COSTCMP2(4),LARPOSN  SET COSTCMP2 = LARGEST + NUMBER
0034C4 D203 210C 213C 0380C 0383C  3595          MVC   COSTCMP3(4),LARPOSN  SET COSTCMP3 = LARGEST + NUMBER
0034CA 9200 23F1      03AF1        3596          MVI   PTPQF,X'00'          SET PTPQF = 0
0034CE 9200 23F2      03AF2        3597          MVI   NPTPQF,X'00'         SET NPTPQF = 0
0034D2 5840 2100            03800  3598          L     4,QIQ                LOAD QUARRY IN QUESTION INTO REG4
0034D6 5890 2068            03768  3599          L     9,SPQCH              LOAD REG9 WITH START PQ CHAIN
0034DA 1299                        3600 AREWDONE LTR   9,9                  ARE WE DONE
0034DC 4740 31EE            03692  3601          BM    PQCRET               IF SO, GO TO PQCRET
0034E0 9140 9006      00006        3602          TM    6(9),X'40'           IS IT A S&G PQ
0034E4 4780 309A            0353E  3603          BZ    ADVPQPTR             IF NOT GO TO ADVPQPTR
0034E8 9180 9006      00006        3604          TM    6(9),X'80'           HAS IT BEEN ZONED OUT
0034EC 4710 309A            0353E  3605          BO    ADVPQPTR             IF SO GO TO ADVPQPTR
0034F0 D500 4007 9007 00007 00007  3606          CLC   7(1,4),7(9)          IS IT OWNED BY SAME OWNER
0034F6 4780 305E            03502  3607          BE    TESTPER              IF SO, GO TO TESTPER
0034FA 9500 9007      00007        3608          CLI   7(9),X'00'           IS IT AVAILABLE - UNOWNED
0034FE 4770 309A            0353E  3609          BNE   ADVPQPTR             IF NOT, GO TO ADVPQPTR
003502 9532 9018      00018        3610 TESTPER  CLI   24(9),50             IS IT AT LEAST 50 PERCENT SAND
003506 47B0 3076            0351A  3611          BNL   TESTGRAV             IF NOT, GO TO TESTGRAV
00350A 43B0 2268            03968  3612          IC    11,DFAREQPR          DOES FINE AGGREGATE REQ PROC
00350E 44B0 31F8            0369C  3613          EX    11,CIFARPR2          ''
003512 4780 3186            0362A  3614          BZ    CUP                  IF NOT GO TO CUP
003516 47F0 3082            03526  3615          B     SETPRI               GO TO SETPRI
00351A 43B0 2269            03969  3616 TESTGRAV IC    11,DCAREQPR          DOES COARSE AGGREGATE REQ PR
00351E 44B0 31FC            036A0  3617          EX    11,CICARPR2          ''
003522 4780 3186            0362A  3618          BZ    CUP                  IF NOT, GO TO CUP
003526 9201 23F1      03AF1        3619 SETPRI   MVI   PTPQF,X'01'          PROCESSING TYPE FOUND SET PTPQF=1
00352A 9101 23F0      03AF0        3620          TM    STRATEGY,X'01'       DO WE WANT TO INVESTIGATE BUILDING
                                   3621 *                                   A PROCESSING PLANT AT THE NEW SITE
00352E 4710 30A2            03546  3622          BO    CWPP                 IF YES, GO TO CWPP
003532 9102 23F0      03AF0        3623 TESTCWIP TM    STRATEGY,X'02'       DO WE WANT TO INVESTIGATE AN IP
003536 4710 3118            035BC  3624          BO    CWIP                 IF YES, GO TO CWIP
00353A 47F0 309A            0353E  3625          B     ADVPQPTR             OTHERWISE, GO TO ADVPQPTR
00353E 5890 9034            00034  3626 ADVPQPTR L     9,52(0,9)            LOAD REG9 WITH ADDR NEXT PQ IN CHAIN
003542 47F0 3036            034DA  3627          B     AREWDONE             GO TO AREWDONE
003546 1B66                        3628 CWPP     SR    6,6                  CLEAR REG6
003548 5870 9010            00010  3629          L     7,16(0,9)            LOAD REG 7 WITH ESTABLISHMENT COST
00354C 5C60 20CC            037CC  3630          M     6,AOEPP              MULT BY ALLOWANCE ON EXISTING PLANT
003550 5D60 3254            036F8  3631          D     6,=F'10'             & DIVIDE BY 10 FOR FRACTION SAVINGS
003554 5860 9010            00010  3632          L     6,16(0,9)            LOAD ESTABLISHMENT COST INTO REG6
003558 1B67                        3633          SR    6,7                  SUBTRACT SAVINGS FROM ESTABLISH COST
00355A 1876                        3634          LR    7,6                  LOAD ACTUAL EST CST INTO REG7
00355C 1B66                        3635          SR    6,6                  CLEAR REG46
00355E 5C60 214C            03840  3636          M     6,HUNDRED            CONVERT EST CST TO PENNIES
003562 5D60 9008            00008  3637          D     6,8(0,9)             DIVIDE BY EXPECTED LIFE
003566 5070 324C            036F0  3638          ST    7,AMORT              STORE AMORTIZATION COST IN AMORT
00356A 4A70 9014            00014  3639          AH    7,20(0,9)            ADD COST TO MINE
00356E D203 20B0 9000 037B0 00000  3640          MVC   POINT1(4),0(9)       SET POINT1 TO LOCATION PQ
003574 9104 23F0      03AF0        3641          TM    STRATEGY,X'04'       DO WE WANT TO FIND LOWEST COST
                                   3642 *                                   FROM PQ(9) TO Q(4)
003578 4710 30E2            03586  3643          BO    SETP2Q4              IF YES GO TO SETP2Q4
00357C D203 20B4 20B8 037B4 037B8  3644          MVC   POINT2(4),WGCPSG     MOVE WGC PROC S&G TO POINT 2
003582 47F0 30E8            0358C  3645          B     PTDET                GO TO PTDET
003586 D203 20B4 4000 037B4 00000  3646 SETP2Q4  MVC   POINT2(4),0(4)       SET POINT 2 TO Q(4)
00358C                             3647 PTDET    EQU   *
00358C 58F0 2034            03734  3648          L     15,ASRDIST           LOAD 15 WITH ADDR SUBROUTINE DIST
003590 05EF                        3649          BALR  14,15                CALL SUBROUTINE DISTANCE
003592 D203 20C4 20A4 037C4 037A4  3650          MVC   TRANSD(4),DISTX      SET DISTANCE PARAMETER
003598 58F0 2038            03738  3651          L     15,ASRTRCST          LOAD 15 WITH ADDR SR TRANS CST
00359C 05EF                        3652          BALR  14,15                CALL SUBROUTINE TRANSPORTATION COST
00359E 5A70 20C8            037C8  3653          A     7,FIXPTCST           ADD TRANS CST PQ9 TO Q4 & Q4 TO WGC
0035A2 5970 2104            03804  3654          C     7,COSTCMP1           IS COST HIGHER THAN PREV LOW COST
0035A6 4720 308E            03532  3655          BH    TESTCWIP             IF YES, GO TO TESTCWIP
0035AA 5090 20F4            037F4  3656          ST    9,ADDRPQ1            STORE ITS ADDR IN ADDRPQ1
0035AE D203 20E8 324C 037E8 036F0  3657          MVC   AMORT1(4),AMORT      STORE AMORTIZATION COST IN AMORT1
0035B4 5070 2104            03804  3658          ST    7,COSTCMP1           STORE NEW LOW COST IN COSTCMP1
0035B8 47F0 308E            03532  3659          B     TESTCWIP             GO TO TESTCWIP
0035BC 4880 9014            00014  3660 CWIP     LH    8,20(0,9)            LOAD COST TO MINE INTO REG8
0035C0 1B66                        3661          SR    6,6                  CLEAR REG6
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                          F01AUG68   5/30/69

0035C2 5870 4CC8            00008  3662          L     7,8(0,4)            LOAD LIFE Q(4) INTO REG7
0C35C6 5D6C 214C            03840  3663          D     6,HUNDRED           DIVIDE BY 100 TO CONVERT TO PENNIES
0C35CA 4C7C 4C2E            0C02E  3664          MH    7,46(0,4)           MULTIPLY BY AMORT$/TON =
                                   3665 *                                  TOTAL REMAINING AMORTIZATION DOLLARS
0C35CE 5D6C 9008            00008  3666          D     6,8(0,9)            DIVIDE REMAINING AMORTIZATION COST
                                   3667 *                                  BY LIFE PQ(9)
0C35C2 5070 2CEC            037EC  3668          ST    7,AMORT2            STORE IN AMORT2
C035D6 1A87                        3669          AR    8,7                 ADD AMORT COST TO REG8
0C35D8 D2C3 2CBC 4CCC C37B0 0C000  3670          MVC   POINT1(4),0(4)      STORE ADDR OF DEPLETED Q IN POINT1
0C35DE D2C3 2CB4 9CCC C37B4 0C0C0  3671          MVC   POINT2(4),0(9)      STORE ADDR OF PQ BEING INVESTIGATED
C035E4 58FC 2C34            03734  3672          L     15,ASRDIST          CALL SUBROUTINE DETERMINE DISTANCE
C035E8 05EF                        3673          BALR  14,15               ''
0C35EA D203 20C4 2CA4 C37C4 037A4  3674          MVC   TRANSD(4),DISTX     MOVE DIST BETWEEN PQ9 & Q4 TO TRANSD
CC35FC 58FC 2C38            03738  3675          L     15,ASRTRCST         CALL SUBROUTINE DETERMINE TRANSPORTA
                                   3676 *                                  TION COST
0035F4 05EF                        3677          BALR  14,15               ''
CC35F6 5A80 20C8            037C8  3678          A     8,FIXPTCST          ADD TRANSPORTATION COST
0035FA D203 20B4 20B8 C37B4 037B8  3679          MVC   POINT2(4),WGCPSG    STORE WGC PROC S&G IN POINT2
0C36CC 58FC 2C34            03734  3680          L     15,ASRDIST          FIND DISTANCE FROM Q4 TO WGC
CC36C4 05EF                        3681          BALR  14,15               CALL SUBROUTINE DISTANCE
CC36C6 D2C3 2CC4 20A4 C37C4 037A4  3682          MVC   TRANSD(4),DISTX     SET DISTANCE PARAMETER
CC360C 58FC 2C38            03738  3683          L     15,ASRTRCST         CALL SR TRANSPORTATION COST
0C361C C5EF                        3684          BALR  14,15               ''
0C3612 5A8C 20C8            037C8  3685          A     8,FIXPTCST          ADD TRANSPORTATION COST
0C3616 598C 21C8            03808  3686          C     8,COSTCMP2          IS COST HIGHER THAN PREV LOW COST
0C361A 4720 309A            0353E  3687          BH    ADVPQPTR            IF YES, GO TO ADVPQPTR
0C361E 509C 2CF8            037F8  3688          ST    9,ADDRPQ2           STORE ITS ADDR IN ADDRPQ2
0C3622 508C 21C8            03808  3689          ST    8,COSTCMP2          STORE COST IN COSTCMP2
0C3626 47FC 309A            0353E  3690          B     ADVPQPTR            GO TO ADVPQPTR
0C362A 92C1 23F2      C3AF2        3691 CUP      MVI   NPTPQF,X'01'        A NON-PROCESSING TYPE FOUND
                                   3692 *                                  SET NPTPQF = 1
0C362E 1B66                        3693          SR    6,6                 CLEAR REG6
0C363C 5870 901C            0C010  3694          L     7,16(0,9)           LOAD EST CST PQ(9) INTO REG7
0C3634 5C6C 214C            03840  3695          M     6,HUNDRED           CONVERT EST COST TO PENNIES
0C3638 5D6C 9CC8            0C008  3696          D     6,8(0,9)            DIVIDE BY LIFE
0C363C 5C70 324C            036F0  3697          ST    7,AMORT             STORE AMORTIZATION COST IN AMORT
0C364C 4A70 9014            0C014  3698          AH    7,20(0,9)           ADD COST TO MINE
0C3644 D2C3 2CB0 9CCC C37B0 0CCC0  3699          MVC   POINT1(4),0(9)      STORE ROW & COL OF PQ(9) IN POINT1
0C364A 91C4 23FC      C3AF0        3700          TM    STRATEGY,X'04'      DO WE WANT TO FIND LOWEST COST
                                   3701 *                                  FROM PQ(9) TO Q(4)
0C364E 471C 31B8            0365C  3702          BO    SETP2QIQ            IF YES GO TO SETP2QIQ
0C3652 D2C3 2CB4 2CBC C37B4 037BC  3703          MVC   POINT2(4),WGCUPSG   SET POINT2 = WGC UNPROCESSED S&G
0C3658 47FC 31BE            03662  3704          B     PT2DET              GO TO PT2DET
0C365C D203 2CB4 4CCC C37B4 0C0C0  3705 SETP2QIQ MVC   POINT2(4),0(4)      SET POINT 2 TO Q(4)
0C3662                             3706 PT2DET   EQU   *
0C3662 58FC 2C34            03734  3707          L     15,ASRDIST          CALL SUBROUTINE DISTANCE
0C3666 05EF                        3708          BALR  14,15               ''
0C3668 D203 2CC4 20A4 C37C4 037A4  3709          MVC   TRANSD(4),DISTX     SET DISTANCE PARAMETER
0C366E 58FC 2C38            03738  3710          L     15,ASRTRCST         CALL SUBROUTINE TRANSPORTATION COST
0C3672 C5EF                        3711          BALR  14,15               ''
0C3674 5A7C 2CC8            037C8  3712          A     7,FIXPTCST          ADD TRANSPORTATION COST TO REG7
0C3678 597C 210C            0380C  3713          C     7,COSTCMP3          IS COST HIGHER THAN PREVIOUS LOW
0C367C 472C 3C9A            0353E  3714          BH    ADVPQPTR            IF YES, GO TO ADVPQPTR
CC368C 509C 20FC            037FC  3715          ST    9,ADDRPQ3           STORE ITS ADDR IN ADDRPQ3
0C3684 507C 21CC            0380C  3716          ST    7,COSTCMP3          STORE ITS COST IN COSTCMP3
0C3688 D2C3 20FC 324C C37F0 036F0  3717          MVC   AMORT3(4),AMORT     STORE AMORTIZATION COST IN AMORT3
0C368E 47FC 309A            0353E  3718          B     ADVPQPTR            GO TO ADVPQPTR
0C3692                             3719 PCCRET   EQU   *
0C3692 58DC 32C8            036AC  3720          L     13,SAVPQC+4
0C3696 98EC DCCC            0C00C  3721          LM    14,12,12(13)
0C369A C7FE                        3722          BR    14
0C369C 91CC 9C16      C0016        3723 CIFARPR2 TM    22(9),X'00'
0C36AC 91CC 9017      CC017        3724 CICARPR2 TM    23(9),X'00'
0C36A4 CCCC36A8                    3725 ASAVPQC  DC    A(SAVPQC)
0C36A8                             3726 SAVPQC   DS    18F
0C36FC                             3727 AMORT    DS    F
0C36F8                             3728          LTORG
CC36F8 COCCCCOA                    3729                =F'10'
                                   3730          DROP  3
                                   3731 ************************************************************
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                              F01AUG68    5/30/69

003700                             3733 COMMON   DS    0D
003700                             3734 DW       DS    D
003708 00003700                    3735 ACOMMON  DC    A(COMMON)
00370C 00003A50                    3736 AOSQ     DC    A(OUTSDQ)              ADDR OF OUTSIDE QUARRIES
003710 00003C78                    3737 AMATRIX  DC    A(MATRIX)
003714 00000000                    3738 ASRAQ    DC    V(SRAQ)
003718 00000000                    3739 ASRAPQ   DC    V(SRAPQ)
00371C 00000000                    3740 ASRADEV  DC    V(SRADEVFO)
003720 00000000                    3741 ASRAWIP  DC    V(SRAWIP)
003724 00000000                    3742 ASRDQ    DC    V(SRDQ)
003728 00000000                    3743 ASRDPQ   DC    V(SRDPQ)
00372C 00000000                    3744 ASRDDEV  DC    V(SRDDEVFO)
003730 00000000                    3745 ASRDWIP  DC    V(SRDWIP)
003734 00000000                    3746 ASRDIST  DC    V(SRDIST)
003738 00000000                    3747 ASRTRCST DC    V(SRTRCST)
00373C 00000000                    3748 ASRWGC   DC    V(SRWGC)
003740 00000000                    3749 ASRADEPP DC    V(SRADEPP)             ADDR SUBROUTINE SRADEPP
003744 00000000                    3750 ASRPQCST DC    V(SRPQCOST)
003748 00000000                    3751 ACARDIN  DC    V(CARDIN)
00374C 00000000                    3752 ALINEOUT DC    V(LINEOUT)
003750 00000000                    3753 ABEGINIT DC    V(BEGINIT)
003754 00000000                    3754 AMINEDP  DC    V(MINEDP)
003758 00000000                    3755 ASRPPU   DC    V(SRPPU)
00375C 00000000                    3756 ASRFLCQ  DC    V(SRFLCQ)
003760 FFFFFFFF                    3757 MINONE   DC    F'-1'
003764 FFFFFFFF                    3758 SQCH     DC    F'-1'
003768 FFFFFFFF                    3759 SPQCH    DC    F'-1'
00376C FFFFFFFF                    3760 SDEVFOCH DC    F'-1'
003770 FFFFFFFF                    3761 SWIPCH   DC    F'-1'
003774 FFFFFFFF                    3762 TQCH     DC    F'-1'
003778 FFFFFFFF                    3763 TPQCH    DC    F'-1'
00377C FFFFFFFF                    3764 TDEVFOCH DC    F'-1'
003780 FFFFFFFF                    3765 TWIPCH   DC    F'-1'
003784                             3766 AQTBA    DS    F
003788                             3767 APQTBA   DS    F
00378C                             3768 ADEVTBA  DS    F
003790                             3769 AWIPTBA  DS    F
003794                             3770 AQTBD    DS    F
003798                             3771 APQTBD   DS    F
00379C                             3772 ADEVTBD  DS    F
0037A0                             3773 AWIPTBD  DS    F
0037A4                             3774 DISTX    DS    F
0037A8                             3775 PRESUSE  DS    F
0037AC                             3776 TONSTC   DS    F
0037B0                             3777 POINT1   DS    F
0037B4                             3778 POINT2   DS    F
0037B8                             3779 WGCPSG   DS    F
0037BC                             3780 WGCUPSG  DS    F
0037C0                             3781 WGCCS    DS    F
0037C4                             3782 TRANSD   DS    F
0037C8                             3783 FIXPTCST DS    F
0037CC                             3784 ADEPP    DS    F                      ALLOWANCE ON EXISTING PROCESSING PLT
0037D0                             3785 APPTBM   DS    F                      (ADDR PP TO BE MOVED)
0037D4                             3786 ACSQTBE  DS    F                      (ADDR CRUSHED STONE Q TO BE ESTABL)
0037D8                             3787 IDPSGTC  DS    F
0037DC                             3788 IDUSGTC  DS    F
0037E0                             3789 IDCSTC   DS    F
0037E4                             3790 MAXT25   DS    F
0037E8                             3791 AMORT1   DS    F
0037EC                             3792 AMORT2   DS    F
0037F0                             3793 AMORT3   DS    F
0037F4                             3794 ADDRPQ1  DS    F
0037F8                             3795 ADDRPQ2  DS    F
0037FC                             3796 ADDRPQ3  DS    F
003800                             3797 QIQ      DS    F
003804                             3798 COSTCMP1 DS    F
003808                             3799 COSTCMP2 DS    F
00380C                             3800 COSTCMP3 DS    F
003810                             3801 ADDRIP   DS    F
003814                             3802 QASSGNED DS    F
003818                             3803 WIPBE    DS    F
00381C                             3804 TYPQASG  DS    F
003820                             3805 TYPQAUSG DS    F
003824                             3806 TYPQACS  DS    F
003828                             3807 PPUPSG   DS    F
00382C                             3808 PPUUPSG  DS    F
003830                             3809 PPUCS    DS    F
003834                             3810 PPUSAND  DS    F
003838                             3811 PPUGRAVL DS    F
00383C 7FFFFFFF                    3812 LARPOSN  DC    X'7FFFFFFF'
003840 00000064                    3813 HUNDRED  DC    F'100'
003844 000003E8                    3814 THOUSAND DC    F'1000'
003848                             3815 FQADY    DS    F
00384C                             3816 MWTD     DS    F
003850                             3817 MWTDPQ   DS    F
003854                             3818 CCPSG    DS    F
003858                             3819 CCUPSG   DS    F
00385C                             3820 CCCS     DS    F
003860                             3821 CTMPSG   DS    F
003864                             3822 CTMUPSG  DS    F
003868                             3823 CTMCS    DS    F
00386C                             3824 CTPSG    DS    F
003870                             3825 CTUPSG   DS    F
003874                             3826 CTCS     DS    F
003878                             3827 CMWTD    DS    F
00387C                             3828 CMWTDPQ  DS    F
003880                             3829 TOTMATLW DS    F
003884                             3830 TOTCOST  DS    F
003888                             3831 TOTTM    DS    F
```

```
  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                                  F01AUG68   5/30/69

00388C                             3832 TOTTONS  DS     F
0C389C                             3833 CTRCST   DS     F
0C3894                             3834 CTONSOUT DS     F
0C3898                             3835 CCOUTS   DS     F
0C389C                             3836 YCPSG    DS     F
0038AC                             3837 YCUPSG   DS     F
0C38A4                             3838 YCCS     DS     F
0038A8                             3839 YTMPSG   DS     F
0C38AC                             3840 YTMUPSG  DS     F
0C388C                             3841 YTMCS    DS     F
0C38B4                             3842 YTPSG    DS     F
0C3888                             3843 YTUPSG   DS     F
0C388C                             3844 YTCS     DS     F
0C38CC                             3845 YTRCST   DS     F
0C38C4                             3846 YTONSOUT DS     F
0C38C8                             3847 YCOUTS   DS     F
0038CC                             3848 INDEXT   DS     F
0C38CC                             3849 PERCFQ   DS     F
0C38D4                             3850 TRCOST   DS     64H
003954                             3851          DS     F
003958                             3852 HGCONF   DS     F
00395C                             3853 VGCONF   DS     F
0C396C                             3854 SLCONF   DS     F
003964                             3855 COSTINT  DS     H
003966                             3856 MAXYEAR  DS     X
003967                             3857 ASSGNQ   DS     X
0C3968 C7                          3858 DFAREQPR DC     X'07'
003969 CF                          3859 DCAREQPR DC     X'OF'
0C396A                             3860 PLANHORZ DS     X
00396B                             3861 ZLNOZONE DS     X
00396C                             3862 PQINFO   DS     X
0C396E                             3863 IDROW    DS     H
0C397C                             3864 IDCOL    DS     H
0C3972 01                          3865 YEAR     DC     X'01'                INITIALIZE YEAR TO 1
003973 FF                          3866 YRNCTBR  DC     X'FF'
003974 FF                          3867 SWITCH   DC     X'FF'
0C3975 5C5C                        3868 STARSTAR DC     C'**'
0C3977 4C4C404C404C4C4C            3869 INPUT    DC     CL80' '
0039C7 40                          3870          DC     C' '
CC39C8                             3871 CARCONT  DS     X
0039C9 4C4C404C404C4C40            3872 OUTLINE  DC     CL132' '
0C3A5C                             3873          DS     OF
CC3A5C                             3874 OUTSDQ   DS     10CL16
CC3AFC                             3875 STRATEGY DS     X
0C3AF1                             3876 PTPQF    DS     X
0C3AF2                             3877 NPTPQF   DS     X
CC3AF3                             3878 CSPQI    DS     X
CC3AF4                             3879 QCA      DS     X
0C3AF5                             3880 QCAD     DS     X
CC3AF6                             3881 CFA      DS     X
CC3AF7                             3882 QFAD     DS     X
0C3AF8                             3883 ZLAW     DS     X
CC3AF9                             3884 ZLAWD    DS     X
0C3AFA                             3885 OWNER    DS X
0C3AFB                             3886 OWNERT   DS     X
0C3AFC                             3887 QUALT    DS     X
CC3AFD                             3888 TYPET    DS     X
0C3AFE                             3889 IDZL     DS     X
0C3AFF                             3890 IDPERSG  DS     X
0C3BCC                             3891 IDMQPSG  DS     X
0C3BC1                             3892 IDMQUSG  DS     X
0C3BC2                             3893 IDMQCS   DS     X
0C3BC3                             3894 IDYTC    DS     X
0C3BC4                             3895 MATLFOS  DS     X
0C3BC5                             3896 SUPPLIER DS     X
0C3B06                             3897 OUTSI    DS     X
0C3BC7                             3898 LNPP     DS     X
0C3BC8 D8E4C1D9D9E84CC9            3899 M35  DC  C'QUARRY IN GRID  --/,  -/- HAS BEEN REMOVED FROM SYSTEM.'
003B3F E4D5E4E2C5C440D4            3900 M36  DC  C'UNUSED MATERIAL IS  -,---,-/- TONS.'
0C3B62 E3D6D64CD4C1D5E8            3901 M37 DC C'TOO MANY ENTRIES IN TEMPORARY CHAIN (TMEITCH)-SEE PROGRAMMER'
                                   3902 M42  DC  C'QUARRY IN GRID  --/,  -/- CAN NO LONGER BE MINED.  IT WILL RX
0C3B9E D8E4C1D9D9E840C9                             EMAIN IN THE SYSTEM AS AN INTERMEDIATE POINT.'
                                   3903 MDPQAQ   DC     C'POTENTIAL QUARRY IN GRID  --/,  -/- IS ESTABLISHED AS X
0C3CC7 D7D6E3C5D5E3C9C1                                 A QUARRY'
0C3C45 C2C5C7C9D540E8C5            3904 BYM      DC     C'BEGIN YEAR -/-'
0C3C53 E2E3C1E3C5D4C5D5            3905 M100     DC     CL36'STATEMENT          HAS BEEN EXECUTED'
0C3C78                             3906          DS 0D
0C3C78                             3907 MATRIX   DS     1000CL84
                                   3908          END
```

PROPERTY OF
Bureau of Land Management
DSC LIBRARY

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225